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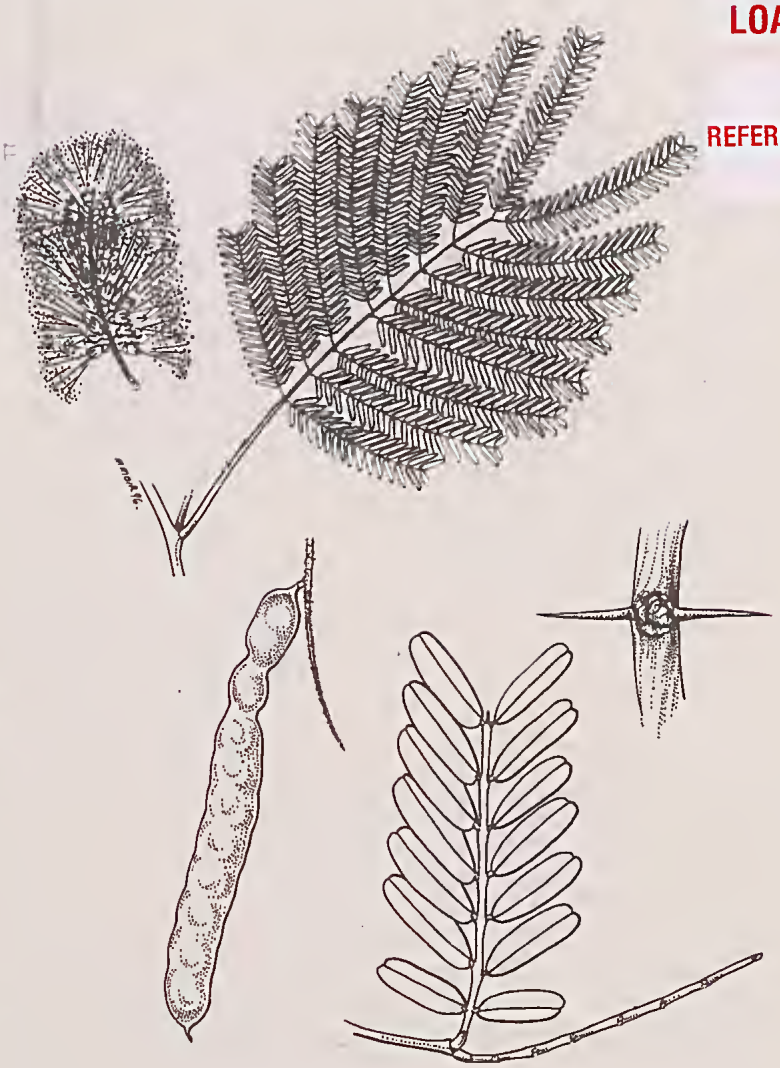

***Paraserianthes lopantha* (Willd.) I.C.Nielsen** [*Flora of Victoria*, v.3, fig. 133 (1996)]
Source: State Botanical Collection
Artist: M. Moir
Cape Wattle is a fast growing shrub/tree endemic to south-west Western Australia and Indonesia. While it has been planted for reforestation programs, as ornamental and shade trees, used as food, firewood, and also as substitute for soap, it has also become a significant worldwide weed.

Muelleria publishes research papers on Southern Hemisphere plant, algal and fungal taxonomy and systematics, particularly relating to Australia. Acceptable submissions include: taxonomic revisions; phylogenetic and biogeographical studies; short papers describing new taxa, documenting nationally significant new records, or resolving nomenclatural matters; historical analyses relevant to systematics; and any research contributing to our knowledge of plant, algal or fungal diversity. Special issues or reviews will also be considered after discussion with the Editor.

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Contents

Volume 29(1) 2011

Royal Botanic Gardens Melbourne

Contributed Papers

Page

Six new infraspecific taxa in *Eucalyptus* (Myrtaceae) for Victoria 3
– K. Rule

Two new mallee Eucalypts (Myrtaceae) from Gippsland, Victoria 16
– K. Rule and W.M. Molyneux

Arthonia banksiae (lichenised ascomycetes) and its synonyms 27
– G. Kantvilas and V. Stasjic

An etymology of Australian bryophyte genera. 2 — Mosses 33
– D. Meagher

New combinations in *Dendrobium* (Orchidaceae) 62
– A. Schuiteman and P.B. Adams

New combinations and two new central Queensland taxa in the *Dendrobium tetragonum* (Orchidaceae:Epidendroideae) complex 69
– P.B. Adams

A new hierarchy conserving nomenclature for the *Dendrobium speciosum* complex (Orchidaceae: Epidendroideae) 81
– P.B. Adams, J.M. Burke and S.D. Lawson

Isolation, characterisation and transferability of microsatellites for *Paraserianthes lophantha*, Cape Wattle (Leguminosae: Mimosoideae): a significant weed worldwide 87
– G. Brown and S. Gardner

Short communication

Development and cross-species amplification of microsatellite markers from the endangered Wee Jasper Grevillea (*Grevillea iaspicula*, Proteaceae) 93
– S. Hoebbee

Six new infraspecific taxa in Eucalyptus (*Myrtaceae*) for Victoria

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Introduction

The six new taxa described here are some of several recently discovered, unnamed eucalypts occurring in Victoria. Others will be treated in future papers. All six are markedly restricted and are described as subspecies within three existing species. Two subspecies occur in the Wimmera region; *Eucalyptus viminalis* Labill. subsp. *siliceana* Rule is from the Wail State Forest, and *E. goniocalyx* F. Muell. ex Miq. subsp. *viridissima* Rule is from Mt. Arapiles and in parts of the northern Grampians. Three subspecies occur near Bacchus Marsh; *E. goniocalyx* F. Muell. ex Miq. subsp. *laxa* Rule, is from the Brisbane Ranges to the south-west of Bacchus Marsh, *E. goniocalyx* F. Muell. ex Miq. subsp. *fallax* Rule in the Blackwood Range to the north-west of Bacchus Marsh, and *E. baueriana* Schauer subsp. *thalassina* Rule is from the Werribee River catchment area. *Eucalyptus baueriana* Schauer subsp. *deddickensis* Rule is from the Deddick River in East Gippsland. The affinities, ecology, distribution and conservation status of each taxon are discussed.

Materials and Methods

Seedlings of all taxa described below were raised both in the nursery of the Melbourne Botanic Gardens and in private nursery facilities using standard native plant potting mixes. As well as for comparing these seedlings with those representing provenances of the typical forms of each species, another important purpose of these progeny trials has been to determine whether any of these very restricted taxa have been derived from hybrid stock. Leaf thicknesses of fresh adult leaves collected in the field were measured using a dial calliper.

Taxonomy

Series Viminales Blakely
MANNA GUM COMPLEX

Eucalyptus viminalis was described in 1806. *Eucalyptus pryoriana* L.A.S.Johnson was described in 1962 on the basis of its persistent rough bark extending to the upper branches, but was changed to a subspecies of *E. viminalis* by Brooker and Slee (1996). Its distribution

Abstract

Six new subspecies *af Eucalyptus* are described fram Victoria, a rough-barked manna gum, *E. viminalis* subsp. *siliceana*, three lang leaf boxs', *E. goniocalyx* subsp. *viridissima*, *E. ganiacalyx* subsp. *laxa*, and *E. ganiacalyx* subsp. *fallax*, and two blue baxs' *E. baueriana* subsp. *thalassina*, and *E. baueriana* subsp. *deddickensis*.

Keywords: manna gum, lang-leaf bax, blue-bax, geagraphically restricted

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was given as sandy coastal areas of the Port Phillip region and South Gippsland. *Eucalyptus viminalis* subsp. *cygnetensis* Boomsma was erected in 1980 to cater for South Australian and western Victorian populations of manna gum with persistent box-like bark and 7-flowered inflorescences. The distribution given for South Australia was the southern extremity of the Eyre Peninsula, Kangaroo Island, the Lofty Ranges and the Lower South-east and the Lower Murray Mallee regions and, for Victoria, the South-west and Wimmera regions. However, both Brooker and Slee (1997) and Nicolle (2006) noted that, although the subspecies is predominantly 7-flowered, populations with trees with mixed 3 and 7-flowered inflorescences have been recorded. *Eucalyptus nobilis* L.A.S.Johnson & K.D.Hill was described in 1990 as a tall forest tree of northern New South Wales and south-east Queensland with smooth bark, broadly lanceolate juvenile leaves and 7-flowered inflorescences. *Eucalyptus viminalis* subsp. *hentyensis* Brooker & Slee was described in 2002 to accommodate small trees of the west coast of Tasmania with smooth bark, ovate-lanceolate juvenile leaves and 3 and 7-flowered inflorescences. The taxonomic standing of this taxon has been questioned by some observers, for example, Nicolle (2006).

Although the number of buds per inflorescence of *E. viminalis* subsp. *hentyensis* is mixed, this feature is given as being consistent within all its populations. However, variable inflorescence numbers do occur in low frequencies within *E. viminalis*, mostly in coastal areas of southern Victoria. In my view some of these forms should be regarded as variants within existing subspecies as they are otherwise indistinguishable from normal trees of those subspecies. Brooker and Slee (1996) speculated that mixed 3 and 7-flowered inflorescences occur in populations of *E. viminalis* subsp. *cygnetensis*, to the west of Melbourne and along the south-west coast near Anglesea. Nicolle (2006) also noted the presence of forms, presumably with some aberrant inflorescence numbers, occurring between Port Phillip Bay and Port Campbell and alluded to them being intergrades between subsp. *cygnetensis* and subsp. *pryoriana*. However, trees with 7-flowered inflorescences or a mixture of inflorescences that

Key to the manna gum complex

1	Inflorescences only 3-flowered	2
1:	Inflorescences 7-flowered or mixed 3 and 7-flowered	3
2	Rough bark persistent to the secondary branches	***E. viminalis*** subsp. ***pryoriana***
2:	Rough bark, if present, absent from the upper trunk	***E. viminalis*** subsp. ***viminalis***
3	Inflorescences 7-flowered	4
3:	Inflorescences mixed 3 and 7-flowered	5
4	Bark smooth throughout	***E. nobilis***
4:	Rough bark extending to the major branches	***E. viminalis*** subsp. ***cygnetensis***
5	Bark smooth throughout	***E. viminalis*** subsp. ***hentyensis***
5:	Rough bark present at least to the mid-trunk	6
6	Seedling growth tips glaucous; fruits 4-6 mm diam	***E. viminalis*** subsp. ***siliceana***
6:	Seedling growth tips green; fruits 5-9 mm diam.	7
7	Rough bark confined to the lower trunk	***E. viminalis*** subsp. ***viminalis***
7:	Rough bark extending to at least the major branches	8
8	Rough bark extending to the secondary branches; bark on lower trunk blackish- brown; broadest adult leaves 2 .5 cm wide	***E. viminalis*** subsp. ***pryoriana***
8:	Rough bark extending to upper trunk or major branches; bark on lower trunk light grey; broadest adult leaves 3.5 cm wide	***E. viminalis*** subsp. ***cygnetensis***

are 3 and 7 flowered also occur on the Mornington Peninsula and in South Gippsland to the east of Wonthaggi and, in my view, are difficult to separate from subsp. *pryoriana* on other characters. There are also small occurrences of trees with mixed 3 and 7-flowered inflorescences occurring in the Brisbane Ranges, to the south of Ballarat and in the Grampians which otherwise are inseparable from trees of the typical subspecies. Further, scrubby trees with mostly 3-flowered inflorescences, relatively broad adult leaves and relatively large fruits occur along the coast near Portland. In my view these trees cannot by readily assigned to any existing subspecies and, therefore, are worthy of more study.

Recent surveys of eucalypts in the Wimmera region of western Victoria by the author have led to the discovery of a distinct, markedly restricted manna gum occurring in the Wail State Forest near Dimboola. It is treated here as a new subspecies within *E. viminalis*.

Eucalyptus viminalis Labill. subsp. *siliceana* Rule sp. nov.

Eucalyptus viminalis *subsp.* siliceana: *A subspeciebus aliis foliis juvenilibus angustoribus pruinosis, inflorescentiae 3 et 7 floribus et fructibus minoribus differt.*

Type: Victoria: Wail State Forest, 0.7 km W along Wimmera Track from North Track, 36° 29′ 00″ S. 142° 03′ 01″ E, *K. Rule 2108* and *J. Jeanes*, 13 viii 2008, (holotype: MEL 2324025; isotypes: AD, CANB. NSW).

Umbrageous *trees* to 15 m tall. *Bark* grey-brown, rough, sub-fibrous, thick, deeply furrowed, crusty, persistent to the upper trunk; branches clean, whitish or pale brown, decorticating in short strips or ribbons. *Seedling leaves* elliptical, decussate, sessile, discolorous, pale green. *Juvenile leaves* narrowly lanceolate, opposite, sessile, basally obtuse and sometimes amplexicaul, persisting for numerous pairs, apiculate or acuminate, slightly discolorous, dull, blue-green to sub-glaucous with glaucous growth tips, 4–8 cm long, 0.6–1.2 cm wide. *Intermediate leaves* lanceolate, broader than juvenile leaves, becoming shortly petiolate, disjunct, light green; growth tips lightly glaucous in the growing season. *Adult leaves* lanceolate, petiolate, disjunct, acuminate, thin-textured (0.15–0.24 mm thick), moderately reticulate, dull, blue-green in winter, sub-lustrous, light-green in summer, 8–15 cm long, 1.2–2.3 cm wide; petioles 0.8–1.8 cm long; lateral veins moderately visible, moderately acute (25–35° from mid-vein); intramarginal vein 1–2 mm from margin; oil glands small, irregular, numerous, mostly island. *Branchlets* sometimes faintly pruinose during the growing season. *Inflorescences* simple, axillary, mixed 3 and 7-flowered on individual trees; peduncles, slender, slightly angular, terete, 7–11 mm long. *Floral buds* ovoid, shortly pedicellate, scarred (outer operculum shed in early bud development), sometimes faintly pruinose at anthesis, 3 or 4-loculed, 6–9 mm long, 3–4 mm wide; pedicels 2–4 mm long; operculum conical, often slightly beaked, flush with the hypanthium at the abscission zone, 3–4 mm long; stamens irregularly flexed, all fertile; filaments white; anthers dorsifixed, versatile, oblong-cuneate, dehiscing through longitudinal slits; ovules in 4 vertical rows. *Fruits* ovoid or sub-globoid, sub-sessile or shortly pedicellate, 4–6 mm long (including valves), 4–6 mm wide; rim slightly above the mid-point of the fruit; disc steeply ascending; valves 3 or 4, slightly exserted. *Fertile seeds* black, irregularly ovoid, pointed at one end, tooth-edged, shallowly pitted; hilum ventral.

Flowering period: Autumn.

Additional specimens examined: **VICTORIA**: Wail State Forest, 36° 29′ 22″ S. 142° 02′ 41″ E., *K. Rule 0056,* 27.vi 2000, MEL 2324027; Wail S. F., 36° 29′ 44″ S. 142°.02′ 54″ E., *K. Rule 0211*, 14 iii 2002, MEL 2324026: Wail State Forest, 200 m N of Ironbark Track, 1.5 km SW of Break Track, 36 30 01 S. 142 02 42 E., *D. Cameron* sn 30 ix 2009 (MEL).

Distribution and habitat: *Eucalyptus viminalis* subsp. *siliceana* is known only from the Wail State Forest in the Victorian Wimmera region where it grows in impoverished, deep, white, siliceous sands (Fig.1).

Associated species: *Eucalyptus camaldulensis* Dehnh. subsp. *camaldulensis*, *E. arenacea* Marinson & Ladiges, *E. leucoxylon* F.Muell subsp. *stephaniae* Rule and *E. leucoxylon* subsp. *pruinosa* Boland occur in the Wail State Forest but not with the new taxon which, as far as is known, occurs in pure stands.

Etymology: The epithet is based on the Latin *siliceus* which is an adjectival form of *silex* 'flint' or 'silica'. The suffix *ana* denotes a link between the new taxon and its habitat.

Conservation status: The single population of the new taxon is scattered sparsely through the northern part of the Wail State Forest which is located on the

eastern side of the Wimmera River. Although the exact numbers of the new taxon are not known, it is estimated that between 300 and 400 mature trees exist. Given its small numbers and its location within a state forest where there is no guarantee of long-term protection, in accordance with IUCN (2001) criteria, a conservation status for the new taxon of endangered is recommended.

Discussion: Some features of *E. viminalis* subsp. *siliceana* have raised the question of whether it is a part of the hybrid entity, *E. huberiana* Naudin. Blakely (1934) described *E. huberiana* to accommodate 7-flowered populations of manna gum occurring in Queensland, New South Wales, Victoria and Tasmania. Other features used by Blakely to distinguish the taxon from 3-flowered manna gums were its basal box-like bark, its sometimes sub-glaucous young twigs and buds and its relatively small fruits (6-8 mm long, 5-6 mm diam). Such authors as Pryor and Willis (1954), Pryor (1955) and Boomsma (1972) applied the name to variable populations occurring in western Victoria and south-east South Australia, which were presumed to be natural hybrids between *E. viminalis* and *E. aromaphloia* Pryor & Willis, but are now recognised as *E. sabulosa* Rule and *E. viminalis* subsp. *cygnetensis*. Johnson and Hill (1990) noted that the concept of *E. huberiana* was an aggregate of at least two now recognised taxa (*E. nobilis* and *E. viminalis* subsp. *cygnetensis*), as well as hybrids in the New England region of New South Wales between *E. viminalis* and *E. nova-anglica* Dean & Maiden. They also noted that no type specimen had been designated for *E. huberiana*. In my view, the form of manna gum described here as *E. viminalis* subsp. *siliceana*, is not consistent with the concept of *E. huberiana*, despite the two sharing particular features (box-like bark, glaucousness and small fruits). Progeny trials have indicated that this entity is true-breeding and field studies have revealed uniformity in adult morphology (except for bud number). These, together with its location being in a habitat not consistent with Blakely's description, not only eliminate the possibility that it is a part of *E. huberiana* but reinforce the case for its acceptance as a new taxon.

E. viminalis subsp. *siliceana* is distinguished within

Figure 1. Distribution Map: *E. viminalis* subsp. *siliceana* (open circle with dot); *E. ganiacalyx* subsp. *viridissima* (closed circle); *E. ganiacalyx* subsp. *laxa* (cross); E. *ganiacalyx* subsp. *fallax* (open circle with cross); *E. baueriana* subsp. *thalassina* (closed triangle); *E. baueriana* subsp. *deddickensis* (closed square).

the manna gums by the combination of features which include its umbrageous habit, its thick, crusty, deeply fractured, sub-fibrous, box-like bark, which extends to the major branches, its narrowly lanceolate, dull, blue-green to sub-glaucous juvenile leaves with glaucous growth tips, its sometimes lightly pruinose buds and branchlets, its dull or sub-lustrous, bluish to light green, generally small adult leaves, its mixed 3 and 7-flowered inflorescences and its relatively small, ovoid or globoid fruits with a steeply ascending disc.

Forms of both *E. viminalis* subsp. *viminalis* and *E. viminalis* subsp. *cygnetensis* occur in the Wimmera region but to the south of the new subspecies in habitats of higher rainfall. *Eucalyptus viminalis* subsp. *viminalis* occurs in the Grampians and adjacent areas and differs by its more erect, taller habit, mostly smooth bark, lustrous, green juvenile leaves, greener adult leaves, mostly 3-flowered inflorescences and generally larger fruits with a slightly ascending disc (fruits 6-8 mm long, 5-8 mm diam). *Eucalyptus viminalis* subsp. *cygnetensis,* which occurs on the southern side of the Little Desert, resembles the new subspecies in both habit and bark, but differs by its lustrous and green juvenile leaves, generally larger adult leaves (to 30 cm long, 3.5 cm wide), mostly 7-flowered inflorescences and larger fruits (6-9 mm long, 6-9 mm diam).

Series *Globulares* Blakely
LONG LEAF BOX COMPLEX

The long leaf box complex or the informal Superspecies *Goniocalyx* (Pryor and Johnson 1971) forms a part of the Series *Globulares* as applied by Brooker (1997, 2000) and is used in this context to facilitate some comparisons between closely related taxa. *Eucalyptus goniocalyx* F.Muell. ex Miq., described in 1856, occurs widely throughout New South Wales, Victoria and South Australia and is characterised by its smallish, usually spreading habit (up to 15 m tall), rough, box-like bark, which extends to the upper branches, sessile, orbicular, glaucous juvenile leaves, relatively long, green adult leaves, cylindrical, waisted, sessile buds with opercula variable in shape, size and width in relation to the hypanthium and tightly-packed, sessile, fruits, which are highly variable in both shape and size (cupular, sub-cylindrical, barrel-shaped or obconical and 6-10 mm long, 5-10 mm diam).

E. banksii Maiden, which occurs in northern New South Wales and south-east Queensland, was described in 1905 and differs from *E. goniocalyx* by its broadly ovate or cordate juvenile leaves, its grey-green adult leaves, its shorter peduncle, its squat, ovoid buds with a hemispherical operculum and its smaller, hemispherical fruits (4-5 mm long, 4-5 mm diam.).

Whilst *E. banksii* is morpholocially discrete within the group, *E. nortonii* L.A.S.Johnson, described in 1962, is widely scattered throughout inland areas along the Great Dividing Range in both New south Wales and Victoria and is similar to *E. goniocalyx* in most features (habit, bark, seedlings, adult leaf sizes and bud and fruit shapes and sizes) but differs primarily by its pruinose branchlets, buds and immature fruits and greyish or glaucous adult leaves. Johnson noted that, at its type locality, *E. nortonii* is separable from *E. goniocalyx* by its larger flowers and coarser fruits, but in southern populations in Victoria, the boundaries between the two in these characters are somewhat blurred.

E. volcanica L.A.S.Johnson & K.D.Hill was described in 1990 to accommodate populations occurring in the Nandewar and Warrumbungle Ranges. Its distinguishing features given are its persistent rough bark on the trunk, glaucous, orbicular juvenile leaves, acute conical operculum with a basal constriction and pedicellate, basally-tapered fruits. Although it has similar bark and juvenile leaves to *E. goniocalyx*, the authors regarded it as more closely related to *E. cypellocarpa* L.A.S.Johnson. In this paper, in accordance with Johnson and Hill's assessment, it is not regarded as a member of the *E. goniocalyx* complex and does not figure in the key provided below.

Eucalyptus goniocalyx subsp. *exposa* Nicolle was described in 2000 to accommodate a mallee form of long leaf box occurring in the Northern Flinders Ranges. However, Brooker and Kleinig (1990) had suggested that this taxon might be regarded as a separate species because it differs from the typical eastern Australian form of the species by its unique habitat, stature, habit and juvenile leaves.

Recent studies by this author have shown that three additional taxa within the long leaf box complex are worthy of taxonomic recognition, each of which is recognised here a as subspecies within *E. goniocalyx*. The first occurs at Mt. Arapiles and at several sites in the northern Grampians and is distinguished primarily by

its juvenile leaves. Both the second and third subspecies occur in the Bacchus Marsh area, one restricted to the Brisbane Ranges and the other to the Blackwood Range, each of which is distinguished primarily from the typical subspecies by its unusual bark.

Eucalyptus goniocalyx F.Muell. ex Miq. subsp. *viridissima* Rule subsp. nov.

Eucalyptus goniocalyx *subsp.* viridissima: *A subspeciebus aliis folius juvenilibus viridioribus nitentoribus et operculo hypanthio latiore differt.*

Type: Victoria: Summit of Mt. Arapiles, 36° 45′ 03″ S., 142° 50′ 02″ E., 13 v 2010 *K. Rule 3610,* MEL (isotypes AD, CANB, NSW).

Spreading, often multi-trunked *trees* to 10 m tall. *Bark* light grey, scaly, box- type, persistent on upper trunk and sometimes major branches; branches usually smooth, white or light brown; old bark decorticating in short ribbons. *Seedling leaves* ovate, sessile, decussate, discolorous, blue-green above, whitish below. *Juvenile leaves* orbicular, often emarginate, opposite, sessile, amplexicaul, coarse-textured, discolorous, lustrous, dark green above, pale green below, 3–8 cm long, 3–8 cm wide; growth tips lustrous; seedling stems initially square in cross section but round after about 5 nodes. *Intermediate leaves* ovate, becoming petiolate, disjunct and concolorous. *Adult leaves* lanceolate, falcate, acuminate, moderately reticulate, coriaceous (0.38–0.52 mm thick), lustrous, green, 10–24 cm long, 2–3.2 cm wide; petioles 1.8–3.1 cm long; intramarginal vein 2–3 mm from margin; oil glands regular, numerous, mostly island. *Inflorescences* simple axillary, 7-flowered; peduncles initially broadly flattened, 10–16 mm long, to 3-4 mm wide, becoming angular and thicker with age. *Floral buds* cylindrical, tightly sessile, often slightly waisted at the mid-point, scarred (outer operculum shed in early development), faintly to prominently bicostate, 3 or 4-loculed, 8–13 mm long, 4–6 mm wide; operculum conical, sometimes shortly beaked, wider than the hypanthium, 4–7 mm long; stamens irregularly flexed, all fertile, filaments white; anthers dorsifixed, oblong-cuneate, versatile, dehiscing through longitudinal slits; ovules in 4 vertical rows. *Fruits* obconical, cupular or sub-cylindrical, sessile, faintly to prominently ribbed, 8–12 mm long, 7–10 mm wide, disc more or less level with the rim; valves 3 or 4 slightly exserted. *Fertile seeds* black, irregularly elongated, lacunose; hilum ventral.

Flowering period Autumn.

Key to members of the long leaf box complex

1 Peduncles 2-6 mm long; fruits to 3-6mm long ..... ***E. banksii***
1: Peduncles 5-18mm long; fruits 6-12 mm long 2

2 Branchlets, buds and immature fruits pruinose 3
2: Adult structures non-pruinose 4

3 Smooth-barked mallees ..... ***E. goniocalyx*** subsp. ***exposa***
3: Box-barked trees ..... ***E. nortonii***

4 Juvenile leaves lustrous and green ..... ***E. goniocalyx*** subsp. ***viridissima***
4: Juvenile leaves glaucous or blue-green 5

5 Bark light brown, thin, finely fibrous, peppermint-like, sparsely-fractured (smooth in appearance), extending to the upper trunk ..... ***E. goniocalyx*** subsp. ***fallax***
5: Bark grey to brown, thick, often crusty, tessellated and scaly, box-like, either persisting to the secondary branches or forming a stocking on the lower trunk 6

6 Rough bark only as a stocking on lower trunk; bark above loosely-attached, non-fibrous; bark on branches smooth ..... ***E. goniocalyx*** subsp. ***laxa***
6: Box-like bark extending to the minor branches; bark on lower trunk thick, crusty and deeply fractured, scaly or tessellated above ..... ***E. goniocalyx*** subsp. ***goniocalyx***

***Additional specimens examined*: VICTORIA**: Mt. Victory Road, c. 1 km S of Zumpstein's Res. 37° 05'57" S., 142° 23'40" E., *K. Rule 11903*, 30 ix 2003, MEL 2324029; Mt. Zero car park, 36° 53'25" S., 142° 22'27" E, *K. Rule 93108*, 21 xi 1993 MEL 2324031; Stawell-Halls Gap Road, c 0.4 km NE of Delley's Bridge, 37° 07' 53" S., 142° 31' 37" E., *K. Rule 0102*, 19 iv 2001, MEL 2324030: Red Rocks, Victoria Range, 37° 13' 30" S.,142° 15' 20" E. *K. Rule 5406*, 12 iii 2006, MEL 2324032.

Distribution and habitat: The taxon is known from Mt Arapiles and from sites in the northern extremities of the Grampian Ranges, for example, Mt Zero, the Halls Gap area, above Zumpsteins Reserve on the northern slope of the Serra Range and the Red Rocks area in the Victoria Range. At all sites the taxon occurs on impoverished sandstone derivatives (Fig. 1).

Associated species: On the plateau of Mt. Arapiles the new taxon is the dominant eucalypt where it mixes with *E. leucoxylon* subsp. *stephaniae* but spills down through the gullies into mallee communities containing forms of *E. wimmerensis* Rule, *E. costata* F.Muell., *E. leptophylla* F.Muell., *E. calycogona* Turcz. subsp. *trachybasis* Nicolle and *E. phenax* Brooker & Slee subsp. *phenax*. At Mt. Zero *E. obliqua* L'Her., *E. baxteri* (Benth.) Maiden & Blakely, *E. melliodora* A.Cunn. ex Schauer and *E. sabulosa* occur close to or in association with the new taxon. The population to the south of Zumpsteins Reserve occurs with *E. obliqua* and abuts *E. alaticaulis* Watson & Ladiges at higher altitudes and *E. melliodora* close to Zumpsteins Reserve. The typical form of *E. goniocalyx*, which is the more common long leaf box in the Wimmera and which always occurs on heavier soils, occurs to the north of Zumpsteins Reserve. At Halls Gap *E. baxteri*, *E. obliqua*, *E. viminalis* subsp. *viminalis* and *E. ovata* Labill. var *ovata* occur adjacent to the new taxon, whilst at Red Rocks *E. baxteri* is a common associate.

Etymology: The epithet is based on the combination of the Latin *viridis* "green" plus the suffix *issimus* 'very' which alludes to the brilliantly green-coloured juvenile leaves of the subspecies.

Conservation status: Where it occurs, the new subspecies is locally abundant. Further searches of the northern Grampians may reveal additional populations. Although all known populations occur within protected reserves (the Grampians National Park and Mt. Arapiles – Tooan State Park), in accordance with IUCN (2001) criteria a conservation status of vulnerable is recommended.

Discussion: *E. goniocalyx* subsp. *viridiissima* was regarded by Nicolle (2006) as an unnamed species (*Eucalyptus* sp. 'Mt. Arapiles') but he gave its only distinguishing feature as its lustrous and green juvenile leaves. Whilst its juvenile leaves are strikingly different to those of typical *E. goniocalyx*, it is my opinion that this feature and a few other subtly distinguishing features are insufficient to support a status of species. Hence, this taxon is here treated as a subspecies within *E. goniocalyx*.

The new subspecies is distinguished from the typical subspecies by features which include its lustrous, green, coarse-textured juvenile leaves, reduced amount of box bark, with the old bark shedding in ribbons from the major branches, generally longer peduncles (5-10 (-15) mm long in the typical subspecies), buds with the operculum consistently wider than the hypanthium at the join and generally larger fruits (6-10 mm long, 5-10 mm wide in the typical subspecies). It is also ecologically different as it occurs on well-drained sandy soils usually associated with rocky outcrops rather than the heavy clays that are preferred by the other Victorian subspecies.

In the northern extremities of the Grampian Ranges *E. alaticaulis* often occurs adjacent to the new subspecies, but at higher altitudes. Without an intimate knowledge of the two taxa they can be difficult to separate in the field as both have similar juvenile leaves in colour and lustre, as well as similar adult leaves, buds and fruits. However, in the field *E. alaticaulis* is separable by its mostly smooth-barked trunks. In seedling trials, too, it differs by its broadly ovate juvenile leaves and seedling stems that are square in cross-section and winged.

Eucalyptus goniocalyx F.Muell. ex Miq. subsp. *laxa* Rule subsp. nov.

Eucalyptus goniocalyx *subsp.* laxa*: A subspeciebus aliis cortice laxo et foliis juvenilibus ovatis glaucescentibus differt.*

Type: Victoria: Intersection of Mt. Wallace Road and Old Thompson Road, Brisbane Ranges N. P., 37° 45' 43" S., 144° 14' 51", E., *K. Rule 2209*, 31vii 09, MEL 2324039 (isotypes: AD, CANB, NSW)

Small, often leaning trees 5-12 m tall. *Bark* of mature trees grey, box-type, forming a stocking on the lower

trunk to various heights; bark on upper trunk smooth, white or light grey, covered by loosely attached, light grey strips and plates or less often completely smooth; bark of saplings thin, box-like, light grey, irregularly fractured, loosely attached, extending to upper trunk. *Seedling leaves* ovate, sessile, decussate, slightly discolorous, blue-green to sub-glaucous. *Juvenile leaves* sessile, opposite and amplexicaul for numerous pairs, orbicular, discolorous, sub-glaucous for 4-6 pairs, becoming broadly ovate and blue-green and slightly lustrous on the upper surface, apiculate, soft-textured for numerous pairs, but retaining sub-glaucous growth tips, 4–8 cm long, 4–6 cm wide; seedling stems initially square in cross-section, becoming round after about 5 nodes. *Intermediate leaves* longer and greener than juvenile leaves, becoming concolorous, petiolate and disjunct. *Coppice leaves* green. *Adult leaves* lanceolate, falcate, acuminate, moderately reticulate, coriaceous (0.35–0.47 mm thick) lustrous, green, 12–25 cm long, 1.8–3.2 cm wide; petioles 1.8–3.3 cm long; intramarginal vein 2–3 mm from margin, oil glands regular, numerous, mostly island. *Inflorescences* simple, axillary, 7-flowered; peduncles broadly flattened, becoming angular and thicker with age, 10–16 mm long, 2-3 mm wide. *Floral buds* cylindrical, sessile or sometimes shortly pedicellate, faintly ribbed, slightly waisted at mid-point, scarred (outer operculum shed in early bud development, 3 or 4-loculed, 10–14 mm long, 3 –5 mm wide; pedicels 0-2 mm long; operculum conical, wider than or as wide as the hypanthium at the join, 3–5 mm long; stamens irregularly flexed, all fertile; filaments white; anthers dorsifixed, versatile oblong, dehiscing through longitudinal slits; ovules in 4 vertical rows. *Fruits* barrel-shaped to cupular, basally-tapered, thick-walled, sessile or sometimes shortly pedicellate, often faintly ribbed, 8–10 mm long, 6–8 mm wide; disc descending; valves 3 or 4, enclosed; orifice often narrow. *Fertile seeds* black, irregularly elongated, flattened, lacunose; hilum ventral.

Flowering period Late winter or spring.

***Additional specimens examined*: VICTORIA:** Switch Road, Brisbane Ranges N.P., c. 600 m from Ballan-Geelong Road, 37° 51' 50" S., 144° 14' 51" E., 28 viii 2004, *K. Rule 04109,* MEL 2324037; Clarkes Road, c. 400 m SW of De Motts Road, 37" 53' 57" S., 144° 13' 20" E, 2 xii 2009, *K. Rule 11809,* MEL 2324035; Steiglitz Road, c. 700 m E of Sutherland Creek. 37°" 52' 56" S., 144° 10' 48" E, 4 ix 2009, *K. Rule 7109,* MEL 2324034; Brisbane Ranges N.P., Mt. Wallace Road, 1.3 km NE of intersection with Thompson Road, 37° 45' 27" S., 144° 16' 40" E., 4 ix 2009, *K. Rule 6909,* MEL 2324038.

Distribution and habitat: *E. goniocalyx* subsp. *laxa* occurs in the Brisbane Ranges to the south-west of Bacchus Marsh in well-watered, heavy soils. (Fig 1).

Associated species: *E. aromaphloia* L.D.Pryor & Willis, *E. tricarpa* subsp. *tricarpa* L.A.S.Johnson & Hill, *E. radiata* subsp. *radiata* Sieber ex DC, *E. macrorhyncha* F.Muell. ex Benth., *E. dives* Schauer, *E. viminalis* subsp. *viminalis, E. obliqua, E. baxteri* and *E. ovata* var. *ovata* either occur with or adjacent to *E. goniocalyx* subsp. *laxa*. Populations of typical *E. goniocalyx* also occur in the Brisbane Ranges on drier, more exposed sites but contact with the new subspecies has not been observed.

Etymology: The subspecific epithet is derived from the Latin *laxus* "loose" in reference to the loosely attached bark on the trunk of the new taxon.

Conservation status: The bulk of the numbers of *E. goniocalyx* subsp. *laxa* are protected within the Brisbane Ranges National Park. Only a small number of individuals are known to occur along roadsides and on private property at the southern extremity of the distribution. Initially the taxon was thought to consist of only a few hundred trees but recent surveys by this author, particularly in the southern part of the distribution, the numbers are now thought to exceed 2000 trees. In accordance with IUCN (2001) criteria a conservation status of vulnerable is recommended.

Discussion: Parsons and Kirkpatric (1972) observed that the morphology of this form of long leaf box is intermediate between *E. goniocalyx* and *E. cypellocarpa* in a wide range of juvenile and adult features. They also found from their seedling trials no evidence that would indicate that it was derived from hybrid stock and further concluded that the form has an affinity with *E. goniocalyx*. From my investigations, through seedling trials and field studies, I concur with Parsons and Kirkpatrick's findings entirely. Its lack of persistent box bark throughout its early development of blue-green juvenile leaves and its green coppice leaves are features which might allude to an affinity with *E. cypellocarpa*. However, in my opinion, its buds and fruits, which are mostly sessile, are within the parameters of

E. goniocalyx. For this reason a subspecific position within that species is considered appropriate.

E. goniocalyx subsp. *goniocalyx* differs from the new taxon by its persistent box bark, which extends to the secondary branches, its orbicular, glaucous juvenile leaves and its shorter peduncles (5-10 (-15) mm long).

E. goniocalyx subsp. *viridissima* differs from subsp. *laxa* by its persistent box bark to at least the upper trunk, its lustrous and green, orbicular juvenile leaves, its operculum that is consistently wider than the hypanthium and its generally longer fruits (to 12 mm long in subsp. *viridissima*).

E. goniocalyx subsp. *fallax*, the third new subspecies treated here, differs from subsp. *laxa* by its taller, more erect habit, its persistent, thin, light-brown, sparsely-fractured (smooth in appearance) bark and its orbicular juvenile leaves.

Eucalyptus goniocalyx F.Muell. ex Miq. subsp. *fallax* Rule subsp. nov.

E. goniocalyx *subsp.* fallax*: A subspeciebus aliis habitu majoribus, cortice laeve plus minuvse et pedunculis longioribus differt.*

Type: Victoria: Grassy Gully Track, Lerderderg State Park, 37° 34° 43"S, 144° 22° 01"E. 30 v 2009, *K. Rule 2109, (holotype:* MEL 2324033; isotypes: AD, CANB, NSW)

Erect *trees* to 25 m tall. *Bark* of mature trees dull, light brown, thin, finely fibrous, peppermint-like, sparsely-fractured (smooth in appearance), extending to the upper trunk; bark on branches grey; old bark decorticating in long strips and ribbons: bark of tallish saplings and immature trees light grey, thin and scaly, extending over most of the trunk. *Seedling leaves* ovate, decussate, discolorous, blue-green to slightly glaucous. *Juvenile leaves* broadly ovate to orbicular, emarginate, sessile, amplexicaul, discolorous, blue-green for numerous pairs, 4-8 cm long, 4-8 cm wide. *Intermediate leaves* broadly ovate, petiolate, becoming disjunct, blue-green to green. *Adult leaves* lanceolate, falcate, acuminate, moderately reticulate, coriaceous (0.33 – 0.47 mm thick) lustrous, dark green, 10 –18 cm long, 1.5 –3.2 cm wide; petioles 1.8 – 2.8 cm long; intramarginal vein 2 – 3 mm from margin, oil glands regular, numerous, mostly island. *Inflorescences* simple, axillary, 7-flowered; peduncles broadly flattened, 11–18 mm long, c. 3 mm wide, becoming angular and thicker with age. *Floral buds* ovoid-cylindrical, sub-sessile or shortly petiolate, faintly ribbed, slightly waisted at mid-point, scarred (outer operculum shed in early bud development, 3 or 4-loculed, 7-10 mm long, 3–4 mm wide; operculum conical, slightly contracted at the join, 3-4 mm long; stamens irregularly flexed, all fertile; filaments white; anthers dorsifixed, versatile oblong, dehiscing through longitudinal slits; ovules in 4 vertical rows. *Fruits* cupular or less often slightly obconical, sessile, usually tightly-clustered, rarely faintly ribbed, 7–10 mm long, 5-7 mm diam; rim thick c.1mm wide; disc descending; valves 3 or 4, enclosed. *Fertile seeds* black, irregularly elongated, flattened, lacunose; hilum ventral.

Flowering period: Spring to early summer.

Distribution and habitat: The new subspecies is known only from a single occurrence which is about 2 km to the south of Mt. Blackwood where it grows in a dry, sclerophyllous forest community on shallow clay soils derived from Silurian sandstone (Fig.1).

Associated species: *E. dives, E. radiata, E. aromaphloia, E. baxteri, E. obliqua* and *E. macrorhyncha* occur with the new taxon.

Etymology: The Latin epithet, *fallax* 'false' or 'deceitful', refers to the deceptive appearance of the bark of the new taxon.

Conservation status: The known population consists of about one hundred trees and occurs within the Blackwood Ranges State Park in an area that is relatively secluded. Although it is highly likely that other populations occur in the area, in accordance with IUCN (2001) criteria, a conservation status of endangered is recommended.

Discussion: *E. goniocalyx* subsp. *fallax* is similar to the typical subspecies in most features but differs markedly by its unusual bark, as well as by its taller, more erect habit and its generally longer peduncles (5-12 (-15) mm long in the typical form). The bark of the typical subspecies is box-like to at least the major branches, usually thick and crusty at the base and scaly or tessellated above. The bark of subsp. *fallax* is best described as somewhat peppermint-like, light brown, dull, thin, not appreciably-fractured and superficially smooth in appearance. However, the bark of tallish saplings and immature trees differs from that of the

mature trees, being light grey, thin and scaly. The bark of the new subspecies is not only an aberration within *E. goniocalyx* but distinctive within the Section *Maidenaria* L.D.Pryor & L.A.S.Johnson of which it is a member.

Series *Heterophloiae* Blakely BLUE BOXS'

Eucalyptus baueriana Schauer sens. lat. grows in well-watered, fertile soils near the coast and in adjacent foothills scattered from north-west of Sydney to the Latrobe Valley in the Gippsland region of Victoria, with a disjunct occurrence to the west of Melbourne in the Bacchus Marsh area. Its features include a robust, spreading habit to 20 m tall, orbicular, emarginate, blue-green juvenile leaves (to 8 cm long and wide), which may be present in the mature canopy, sub-lustrous, light green adult leaves (6-9 cm long, 2.5-7 cm wide), buds borne on pedicels (2-6 mm long) and conical or funnel-shaped fruits (6-7 mm long, 4-6 mm diam). *Eucalyptus magnificata* L.A.S.Johnson & K.D.Hill was segregated from *E. baueriana* in 1990 to cater for glaucous, large-fruited blue box populations occurring in northern New South Wales and south-eastern Queensland.

The disjunct populations of blue box occurring to the west of Melbourne in the Werribee River catchment have been long-regarded by local observers as being morphologically different to the typical form of *E. baueriana*. A second morphologically different blue box occurring along the Deddick River in East Gippsland was brought to the attention of MEL about six years ago. My investigations of both of these forms have confirmed that they worthy of taxonomic recognition and, hence, they are treated here as two new subspecies of *E. baueriana*.

Eucalyptus baueriana Schauer subsp. *thalassina* Rule subsp. nov.

Eucalyptus baueriana *subsp.* thalassina: *A subspeciebus aliis habitu minoribus, foliis juvenilibus minoribus, foliis adultis minoribus hebetibus cineraceis vel glaucescentibus et fructibus minoribus differt.*

Type: Victoria: Diggers Rest-Coidamai Road at the Djerriwahrr Creek crossing 37° 37′ 07″ S. 144° 31′ 42″ E. 16 iii 2005 *K. Rule 2005*, MEL 2324023 (Isotypes: CANB, NSW).

Robust, depauperate *trees* or rarely spreading *mallees*, 3-12 m tall. *Bark* grey-brown, box-like, often flaky and loose, persisting to major branches. *Seedling leaves* ovate to orbicular, shortly petiolate, green, opposite for a few pairs. *Juvenile leaves* obcordate, sub-orbicular or orbicular, usually emarginate, disjunct, dull, blue-green, 2-4 cm long, 2-4 cm wide; petioles slender, non-pruinose, 2.4-3.6 cm long. *Intermediate leaves* sub-orbicular or broadly ovate, wider than both juvenile and adult leaves, dull, blue-green, dominating the canopies of saplings and young trees and often persisting in the canopies of mature trees. *Adult leaves* broadly ovate or broadly lanceolate, dull, blue-green to blue-grey, soft-textured (0.15-0.25 mm thick), 3-5 cm long, 2-4 cm wide; petioles 1.5-3 cm long; venation densely reticulate with conspicuous lateral veins and crowded, unbroken veinlets; intramarginal veins looped, 2-3 mm from the margin; oil glands irregular, small, island or intersectional; summer outer canopy dominated by new leaves that are initially light green and develop a bluish tinge as they mature. *Inflorescences* 7-flowered, within leafless, branched, terminal panicles; peduncles slender, 7-12 mm long. *Floral buds* clavate, pedicellate, scarred (outer operculum shed in early bud development), non-pruinose, burnished, 4-5 mm long,

Key for the subspecies of *E. baueriana*

1 Medium trees to 20 m tall; adult leaves sub-lustrous, light green; buds borne on pedicels 2-6 mm long; fruits obconical to funnel-shaped, 6-7 mm long, 4-6 mm diam ..... subsp. ***baueriana***

1: Small trees or mallees to 12 m tall; adult leaves blue-grey to blue-green or sub-glaucous to glaucous; pedicels 0-3 mm long; fruits obconical to slightly cupular, 3-5 mm long, 3-5 mm diam **2**

2 Adult leaves sub-glaucous to glaucous, 5-7 cm long, 4-6 cm wide; fruits 3-4(-5) mm long, 3-4 mm diam. ..... subsp. ***deddickensis***

2: Adult leaves blue-green to blue-grey, 3-5 cm long, 2-4 cm wide; fruits 4-5 mm long 4-5 diam ..... subsp. ***thalassina***

4-5 mm diam; pedicels slender, shorter than the buds, 1-3 mm long; operculum obtuse, c. 2 mm long, as wide as the hypanthium; stamens irregularly inflexed, outer whorls infertile; filaments white, old stamens shed with the staminal ring; anthers adnate, basifixed, globoid, dehiscing through lateral pores; ovules in 4 vertical rows. *Fruits* obconical, shortly pedicellate, thin-walled, 4-5 mm long, 4-5 mm diam.; pedicels 1-3 mm long; disc descending; locules 3 or 4; valves enclosed. *Fertile seeds* brown, irregular ovoid, finely reticulate; hilum ventral.

Flowering period: Late spring or early summer.

Additional specimens examined: Victoria: Long Forest Flora Reserve, steep track at its lowest point, 37° 38′ 33″ S., 144° 29′ 44″ E., 28 xii 2006, *J.A. Jeanes 1628* and *V. Stajsic*, MEL 2296388; Cobbledick Ford Res., on banks of Werribee River, 37° 49′ 10″ S. 144° 35′ 00″ E., *D.E. Albrecht 3281* MEL 1560786; Djerriwarrah, 6km NE of Bacchus Marsh, along tributary of Coidamai Creek, 37° 39′ 00″ S., 144° 29′ 45″ E., 8 i 1985 *S. Forbes 2791*, MEL 678644; Werribee River, Werribee, 100 m upstream from scout hall, at the end of Richmond Cres., 37° 53′ 53″ S. 144° 39′ 13″ E. MEL 2211236; Pinkinton Forest (Mt. Cottrell Woodland), 1.1 km from Mt. Cottrell Road and 1.6 km from Greig Road, 37° 46′ 39″ S., 144° 35′ 39″ E., 10 i 1993 *V. Stajsic 889* MEL 2019805; Exford, Griggs Road West, on the eastern slope above the Werribee River, 37° 44′ 55″ S. 144° 34′ 35″ E., 25 iii 2005, *K. Rule 2805*, MEL 23244024.

Distribution and habitat: The new subspecies grows close to watercourses in alluvial soils in the Werribee River catchment, both downstream from Bacchus Marsh along the Werribee River Valley and to the north-east of Bacchus Marsh along Coidamai and Djerriwahrr Creeks which feed into the Werribee River (Fig. 1).

Associated species: Where it occurs in the northern part of its distribution *E. baueriana* subsp. *thalassina* most often grows in pure populations but may be found close to such species as *E. tricarpa* subsp. *tricarpa*, *E. leucoxylon* subsp. *connata* Rule, *E. polyanthemos* Schauer subsp. *vestita* L.A.S.Johnson & K.D.Hill, *E. polyanthemos* subsp. *marginalis* Rule, *E. goniocalyx* subsp. *goniocalyx*, *E. melliodora*, *E. macrorhyncha*, *E. cephalocarpa* Blakely, *E. behriana* F.Muell., *E. microcarpa* Maiden and *E. dives*, all of which occur on higher, well-drained sites. Along the Werribee River *E. camaldulensis* subsp. *camaldulensis* may be an associate.

Etymology: The epithet is derived from the Latin *thalassinus* 'sea-green' which alludes to the attractive colour of the new summer adult leaves.

Conservation status: The exact numbers of the new subspecies are not known but it is estimated that only a few thousand trees exist, most of which occur in the northern part of the distribution along the Coidamai and Djerriwahrr Creeks which form a part of the Werribee River catchment. The Coidamai Creek, in particular, feeds into the reserve of the Lake Merrimu Reservoir and flows through to the Long Forest Flora Reserve, both of which currently provide protection to substantial numbers of the taxon. In accordance with IUCN (2001) criteria, a conservation status of endangered is recommended.

Discussion: *Eucalyptus baueriana* subsp. *thalassina* differs from the typical subspecies by its smaller habit, smaller juvenile leaves, smaller, duller adult leaves, smaller buds with shorter pedicels and smaller fruits. This new subspecies differs from subsp. *deddickensis* which has larger, sub-glaucous to glaucous adult leaves and generally smaller buds and fruits.

A form of red box, *E. polyanthemos* subsp. *marginalis* Rule, which is a common eucalypt in the Brisbane Ranges and adjacent areas, has been erroneously referred to as *E. baueriana*, possibly because its adult leaves are lustrous and green. This form of red box is mostly found on elevated sites in poor, well-drained soils, whereas *E. baueriana* subsp. *thalassina* occurs along water courses and drainage lines in fertile soils. The red box can be further distinguished by its more or less barrel-shaped, relatively thick-walled fruits and its appreciably coarse, ovate adult leaves.

Eucalyptus baueriana Schauer subsp. *deddickensis* Rule subsp. nov.

Eucalyptus baueriana *subsp.* deddickensis: *A subspeciebus aliis habitu minoribus, foliis adultis glaucis et fructibus minoribus differt.*

Type: *Victoria*: On the bank of the Deddick River, 10 km by road upstream from Ambyne Settlement Road, 37° 02′ 44′ S., 148° 32′ 17′ E., 18 viii 2006, *K. Rule 8106* and *K. Parker*, MEL 23244022 (Isotypes: AD, NSW, CAN)

Small, depauperate, mallee-like *trees*, 4-8 m tall. *Bark* whitish or light grey, thin, box-like, scaly, persisting to major branches; bark on branches smooth, white, shed in short ribbons. *Seedling leaves* ovate to orbicular, shortly petiolate, green, opposite for a few pairs. *Juvenile leaves* obcordate, sub-orbicular or orbicular,

usually emarginate, disjunct, dull, blue-green, 3-5 cm long, 3-5 cm wide; petioles slender, 1.5-2.5 cm long. *Intermediate leaves* sub-orbicular or broadly ovate, dull, blue-green to sub-glaucous, present in the canopies of saplings, young trees and mature trees, larger than adult leave. *Adult leaves* broadly ovate or sub-orbicular, relatively sparse, sub-glaucous to glaucous, thin-textured (0.15-0.25 mm thick), 5-7 cm long, 4-6 cm wide; petioles 1.5-3 cm long; venation densely reticulate with conspicuous lateral veins and crowded, unbroken veinlets; intramarginal veins looped, 2-3 mm from the margin; oil glands irregular, small, island or intersectional. *Inflorescences* 7-flowered, within leafless, branched, terminal panicles; peduncles slender, 6-11 mm long. *Floral buds* clavate, sessile or shortly pedicellate, scarred (outer operculum shed in early bud development), non-pruinose, burnished, 4-5 mm long, 2.5-3.5 mm diam.; pedicels 0-3 mm long; operculum obtuse, 1-2 mm long, as wide as or slightly narrower than the hypanthium; stamens irregularly inflexed, outer whorls infertile; filaments white, old stamens shed with the staminal ring; anthers adnate, basifixed, globoid, dehiscing through lateral pores; ovules in 4 vertical rows. *Fruits* obconical or slightly cupular, sessile or shortly pedicellate, thin-walled, 3-5 mm long, 3-4 mm diam.; pedicels, if present, 1-2 mm long; disc narrow, descending; locules 3 or 4; valves enclosed. *Fertile seeds* brown, irregular ovoid, finely reticulate; hilum ventral.

Flowering period Late spring to early summer.

Additional specimen examined: Victoria: Deddick River, adjacent to Deddick Park Station, 37° 03' 37" S., 148° 30' 45" E., 20 iv 2009, *K. Rule 0209*, MEL 23244021.

Distribution and habitat: *E. baueriana* subsp. *deddickensis* is known only from two restricted, relatively isolated populations on the banks of the Deddick River in East Gippsland where it prefers soils of granite origins (Fig. 1).

Associated species: The new subspecies grows in pure stands but abuts *E. albens* Benth. at its boundaries. Other species occurring in the area include *E. bridgesiana* R.T.Baker, *E. melliodora*, *E. microcarpa* and *E. macrorhyncha*.

Etymology: The epithet refers to the locality where the new taxon occurs.

Conservation status: The subspecies is known from two small populations occurring along the Deddick River on public land where the total number of plants is estimated to be close to 200. However, it is highly likely that other similarly small populations exist in the Deddick River catchment. In accordance with IUCN (2001) criteria, a conservation status of endangered is recommended.

Discussion: The new subspecies is considered to be closely related to *E. baueriana* despite it resembling some glaucous forms of *E. polyanthemos* subsp. *vestita* which also occur in East Gippsland. However, its riparian habitat, thin-textured adult leaves, clavate buds and thin-walled, conical fruits indicate that it is a form of *E. baueriana*. The typical subspecies of *E. baueriana* also occurs in the region of East Gippsland but in sub-coastal and coastal forests on deep, fertile soils. *E. baueriana* subsp. *baueriana* further differs from the new subspecies by its more robust, taller habit, sub-lustrous, light green adult leaves, larger buds, which are usually borne on longer pedicels, and larger fruits.

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Two new mallee Eucalypts (Myrtaceae) from Gippsland, Victoria

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Abstract

Two new species of the subgenus *Eucalyptus* are described. *Eucalyptus ornans*, Avon Peppermint, is an extremely rare mallee form of peppermint of the series *Radiotae* occurring at the Avon Channels to the north of Maffra in the Central Gippsland region of Victoria. *Eucalyptus forresterae*, Brumby Sallee, is a restricted, shrubby or whipstick mallee of the series *Longitudinales* occurring near Nunniong Plateau and above Buchan River Falls at Native Dog Flat in East Gippsland. The distribution, ecology, affinity and conservation status of each taxon are discussed, as are the morphological features of the series to which each belongs.

Keywords: mallee, peppermint, series *Radiatoe*, series *Longitudinoles*

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Introduction

Eucalyptus ornans Rule & Molyneux (series *Radiatae* Chippend., subgenus *Eucalyptus* L'Hér.) and *E. forresterae* Molyneux & Rule (series *Longitudinales* Blakely, subgenus *Eucalyptus)* are new species that occur in relatively remote and inaccessible areas of eastern Victoria. Both are highly restricted, lignotuberous mallees interpreted as relictual species which evolved in extremely cold conditions in the late Quaternary permafrost period and survived competition from migrating forest species as the climate of south-eastern Australia became warmer in the Holocene.

Terminology

The term 'glaucous', when applied to leaf colour, means whitish and not blue-green. The term 'pruinose' refers to the waxy bloom occurring on seedling and adult structures.

Methods

Seedling trials using selected seedlots of both *Eucalyptus ornans* and *E. forresterae* and their closest relatives (*E. elata* Dehnh. and *E. stellulata* Sieber ex DC. respectively) have been conducted at private nursery facilities and in the nursery of the Royal Botanic Gardens Melbourne. Seedlots for *E. elata* have been drawn from populations in Central and East Gippsland and south-east New South Wales, and for *E. stellulata* from East Gippsland and adjacent areas of New South Wales and from the New England Plateau of that state. Both new species have been studied at the seedling stage and in cultivation as saplings and mature plants. Cultivated adult plants of *E. ornans* were planted in 2000 as advanced seedlings and those of *E. forresterae* in 1994, also as mature seedlings. Our studies of adult materials involved the examination of herbarium specimens and field studies of populations not only of the new species but also of their close relatives. Leaf thickness using fresh adult leaves has been measured using a dial caliper.

Series *Radiatae*

Species of series *Radiatae* are mostly confined to the Australian mainland with only an outlier of *Eucalyptus radiata* Sieber ex DC.

occurring in Tasmania. Brooker (2000) erected series *Insulanae* Brooker for the remaining Tasmanian peppermints, a fundamental difference between the two series being that the species of series *Insulanae* possess raised glands along the margins of the juvenile leaves whereas members of series *Radiatae* do not.

Series *Radiatae* contains the narrow-leaved Peppermints (*E. radiata* subsp. *radiata* Sieber ex DC., *E. radiata* subsp. *sejuncta* L.A.S.Johnson & K.D.Hill, *E. robertsonii* Blakely (syn. *E. robertsonii* subsp. *robertsonii* and *E. radiata* subsp. *robertsonii* (Blakely) L.A.S.Johnson & Blaxell) and *E. croajingolensis* L.A.S.Johnson & K.D.Hill), the shining or broad-leaved peppermints (*E. dives* Schauer, *E. willisii* Ladiges, Humphries & Brooker, *E. molyneuxii* Rule, *E. falciformis* (Newnham, Ladiges & Whiffin) Rule and *E. arenicola* Rule) and the river peppermints (*E. elata* Dehnh. and *E. ornans* Rule & Molyneux, the mallee peppermint treated here as a new species). Johnson and Hill (1990) erected *E. robertsonii* subsp. *hemisphaerica* L.A.S.Johnson & K.D.Hill to accommodate populations occurring in the vicinity of Orange, New South Wales. Rankin (1998), in his study of the wider peppermint group concluded, however, that the taxon is a natural hybrid between *E. robertsonii* and *E. dives*. We accept Rankin's interpretation and exclude subspecies *hemisphaerica* from the key below.

The narrow-leaved peppermints are trees that feature rough bark to the secondary branches, raised glands persisting on the stems throughout the juvenile stage, numerous pairs of opposite, sessile, amplexicaul juvenile leaves, thin adult leaves and smallish, thin-walled fruits. The shining or broad-leaved peppermints as a group are variable in habit (trees or mallees), bark

Key to series *Radiatae*

1	Juvenile leaves petiolate and vertically-oriented	2
1:	Juvenile leaves sessile, opposite, amplexicaul and horizontally-oriented for numerous pairs	3
2	Adult leaves 50–100 mm long; fruits 4–6 mm diameter	***E. molyneuxii***
2:	Adult leaves to 70–170 mm long; fruits 6–8 mm diameter	***E. falciformis***
3	Bark smooth throughout or a stocking of compact bark present on the lower trunk	4
3:	Bark rough (peppermint type) extending to at least upper trunk	5
4	Mallee; bark smooth throughout; sub-glaucous intermediate leaves persistent in the mature canopy	***E. ornans***
4:	Tree; a stocking of finely fissured, compact bark present; mature canopy consisting entirely of lustrous and green adult leaves	***E. elata***
5	Robust, spreading mallees	6
5:	Small to tall trees	7
6	Adult leaves lustrous and green; fruits 6–9 mm diameter	***E. arenicola***
6:	Adult leaves dull or sub-lustrous and blue-green; fruits 4–6 mm diameter	***E. willisii***
7	Juvenile leaves sub-glaucous or glaucous, ovate or broadly ovate; adult leaves to 30 mm wide	***E. dives***
7:	Juvenile leaves green or blue-green, lanceolate (narrow to broad); adult leaves to 15 mm wide	8
8	Adult leaves slightly blue-green or green	9
8:	Adult leaves blue-grey	10
9	Juvenile leaves narrowly lanceolate or lanceolate	***E. radiata*** subsp. ***radiata***
9:	Juvenile leaves broadly lanceolate	***E. radiata*** subsp. ***sejuncta***
10	Juvenile leaves narrowly lanceolate; operculum sharply conical	***E. robertsonii***
10:	Juvenile leaves lanceolate; operculum obtuse or hemispherical	***E. croajingolensis***

(almost smooth-barked to rough bark extending to the minor branches) and seedling characters (petiolate, vertically-oriented pairs of juvenile leaves or numerous pairs of opposite, sessile, amplexicaul, horizontally-oriented pairs of juvenile leaves). However, their seedlings consistently exhibit prominently raised glands on the stems only in the early stages of development, coarse-textured adult leaves and thick-walled fruits. Lastly, the river peppermints feature either smooth bark throughout, as in *E. ornans*, or smooth bark with a stocking of grey to black, finely fissured, compact bark, as in *E. elata*, numerous pairs of narrowly lanceolate, opposite, sessile, amplexicaul juvenile leaves, seedlings that retain prominently raised glands on the stems for numerous pairs and narrowly lanceolate adult leaves and slightly cupular to globular-truncate, thin-walled fruits.

Taxonomy

Eucalyptus ornans Rule & Molyneux sp. nov.

Eucalypto elatae *affinis habitu 'malleeformibus', cortice omnino laevis albescentibus, foliis juvenilibus glaucescentibus, foliis mediis glaucescentibus persistentibus, foliis adultis minoribus et fructibus minoribus differt.*

Type: Victoria. Avon Channels, 37° 48' 20" S 146° 52' 34" E, 14.iv.2005, *K. Rule 3805* (MEL2328846, AD, CANB, NSW).

Small, slender *mallees*, 4–10 m tall; stems erect; branchlets semi-pendulous. *Bark* smooth, whitish when new; old bark light grey, decorticating in short strips and ribbons; thin, loose bark often accumulating about the base. *Seedling stems* round in cross-section; lignotuber present in seedling stage; prominently raised glands present, persisting until the sapling stage. *Seedling leaves* decussate, narrowly lanceolate, sessile, discolorous, light green above, whitish below. *Juvenile leaves* narrowly lanceolate, opposite, sessile, amplexicaul and horizontally-oriented for numerous pairs, acuminate, strongly discolorous, blue-green above, whitish below, 50–80 mm long, 7–12 mm wide. *Intermediate leaves* slightly broader than juvenile leaves, sessile or shortly petiolate, basally rounded, becoming diagonally-oriented, discolorous, sub-glaucous, dominating the canopy of saplings and persisting in the canopy of mature mallees; growth tips lightly pruinose. *Adult leaves* narrowly lanceolate, disjunct, shortly petiolate, acuminate, sparsely reticulate, concolorous, sub-lustrous, blue-green, 60–110 mm long, 8–12 mm wide; petioles 6–12 mm long; leaf base tapered; venation sparsely reticulate; lateral veins acute, <30° from mid-vein; intramarginal vein <2 mm from margin; faint secondary intramarginal vein present, <1 mm from margin; oil glands numerous, small, regular, island. *Inflorescences* simple, axillary, 17–21-flowered; peduncles slender, slightly angular, 5–12 mm long. *Floral buds* fusiform, unscarred, c. 4 mm long, 2–3 mm diameter; pedicels slender, 6–10 mm long; hypanthium widest just below the abscission zone; operculum single, conical, c. 2 mm long, to 2 mm wide; stamens inflexed, all fertile; filaments white; flowering period summer; anthers versatile, sub-basifixed, reniform, dehiscing through diagonal slits; ovules in 2 vertical rows. *Fruits* globular-truncate, pedicellate, c. 4 mm long, c. 4 mm wide; pedicels 4–7 mm long; disc descending; valves enclosed; locules 3–4. *Fertile seeds* irregularly cuboid or pyramidal, blackish; hilum terminal (Fig. 1).

Figure1. Distribution map of: *E. ornans* (circle): *E. forresterae* (square).

Distribution and habitat: *Eucalyptus ornans* occurs as a single known population to the north of Maffra on the banks of the Avon River (in the Avon–Mount Hedrick Natural Features Scenic Reserve) in the Central Gippsland region of Victoria. The species grows in coarse gravels around a narrow, lake-like outlet of the Avon Channels (Fig. 2).

Additional specimen examined: **VICTORIA.** Avon Channels, 37°48'S, 146°52'E, 22.vii.2001, *W. Molyneux s.n.* (MEL 2330513).

Associated species: *Eucalyptus ornans* grows in association with *E. bridgesiana* R.T.Baker, *E. cephalocarpa* Blakely, *E. consideniana* Maiden, *E. cypellocarpa* L.A.S.Johnson and *E. globoidea* Blakely at its margins on higher, drier sites. Other species, including *E. goniocalyx* F.Muell. ex Miq. subsp. *goniocalyx*, *E. macrorhyncha* F.Muell., *E. melliodora* A.Cunn. ex Schauer, *E. polyanthemos* Schauer subsp. *vestita* L.A.S.Johnson & K.D.Hill, *E. muelleriana* A.W.Howitt, *E. sieberi* L.A.S.Johnson and *E. tricarpa* L.A.S.Johnson & K.D.Hill subsp. *tricarpa*, occur in the immediate vicinity.

Etymology: The epithet is derived from the Latin *ornatus* 'ornate' in reference to the highly ornamental nature of the species.

Recommended English name: Avon Peppermint.

Conservation status: In earlier surveys of *Eucalyptus ornans* by each of the authors, a total of c. 70 mature individuals were recorded from both banks of the Avon River. Following the severe flooding of the river in 2007, all but 10 individuals were washed away. Because of this small population size and area of occupancy less

Figure 2. *Eucalyptus ornans* a) mallees prior to 2007 flooding of the Avon River (Rule, 13/9/06); b) canopy of immature mallee (Rule, 13/9/06); c) buds and fruits (*Rule 3805*)

than 1 ha, and with ongoing risk of flooding resulting in further population reduction, *E. ornans* is assessed as critically endangered under the IUCN Red List categories and criteria (IUCN 2001) with a threat code of CR B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v); C2a(i,ii); D.

Discussion: *Eucalyptus ornans* is closely related to *E. elata*, which is typically a forest tree (to 45 m tall) occurring along fertile river valleys of Gippsland and the South Coast region of New South Wales, occasionally extending to more elevated sites. Many of the features which the two species share are discussed above. Other shared features include adult leaves with a sparse reticulation and numerous, small, regular island glands, inflorescences with slender peduncles and numerous buds per umbel, small, clavate or fusiform buds with long pedicels and relatively small fruits with a descending disc and 3 or 4 valves.

Apart from its habit, *E. elata* differs from the new species by its pendulous branches, its stocking of compact bark which covers the lower trunk, its longer adult leaves (80–170 mm long), its larger fruits (4–6 mm diameter), which are borne on short, thick pedicels, and its mature canopy of strictly adult leaves (Table 1).

Outliers of *E. elata* have been recorded in Central Gippsland along the Macalister and Avon Rivers. In fact, it is worth noting that a small, but typical, population of *E. elata* occurs along the Avon River a few kilometres downstream of the new species.

In cultivation, plants of more than 10 years old of *E. ornans* retain those features which characterise the species, particularly the development of the lignotuber, the mallee habit and the sub-glaucous pre-adult leaves which dominate the canopy of saplings and more mature plants.

Depauperate trees and mallee forms of *E. elata*, often with adult features generally smaller than typical and canopies consisting entirely of adult leaves are found on dry ridges and slopes in Central Gippsland, East Gippsland and South Coast New South Wales. Hill (2002), Brooker and Slee (1996, 1997) and Nicolle (2006) included these forms with the typical riparian form of the species. The taxonomic status of these populations requires further investigation. Our study of these was postponed when many populations were severely burnt in the 2003 bushfires that swept over large areas of East Gippsland.

The riparian location of *E. ornans* on the Avon River, its small population size, now of about 10 mature individuals, and its mallee habit, which contrasts with a number of sympatric species of *Eucalyptus* of tree form, raise interesting questions regarding its evolution.

In our description of *E. forresterae* (below) we suggest that that species developed a mallee habit as a survival strategy in response to late Quaternary permafrost associated with Kosciuszko periglacial conditions. We suggest it is equally plausible that *E. ornans* also evolved as a mallee in the same period. Hope (1994), in his discussion regarding the evolution of the mallee habit in eucalypts under dry arid conditions, states that the development of lignotubers in cold mountain

Key to series *Longitudinales*

1	Single or few-stemmed trees to 20 m tall	2
1:	Multi-stemmed, whipstick or shrubby mallees to 6 m tall	4
2	Bark compact and black at the base, olive-green above; juvenile leaves broadly ovate	*E. stellulata*
2:	Bark smooth throughout; juvenile leaves narrowly elliptical	3
3	Fruits 4–6 mm long, 4–5 mm diam	*E. copulans*
3:	Fruits 5–7 mm long, 5–7 mm wide	*E. mitchelliana*
4	Juvenile leaves orbicular or cordate, amplexicaul	*E. forresterae*
4:	Juvenile leaves narrowly lanceolate, lanceolate, elliptical or ovate, basally discrete	5
5	Adult leaves erect, 40–100 mm long, 8–20 mm wide	*E.moorei* subsp. *moorei*
5:	Adult leaves semi-pendulous, 40–120 mm long, 4–10 mm wide	*E. moorei* subsp. *serpentinicola*

regions during the Quaternary reflects a common strategy that enhances regeneration and survival under growth-limiting conditions.

The Avon River (the only known locality for *E. ornans*) rises on the southern flanks of the Mount Wellington massif which, even now, has an extensive snow cover in winter. This would have been a much colder environment during the Quaternary. As we note below with some populations of *E. forresterae*, *E. ornans* is now associated with a number of common tree-form eucalypts which have apparently migrated into its habitat in response to warming conditions during the Holocene.

Series *Longitudinales*

Mallees of the series *Longitudinales* occur on and north of the Nunniong Plateau at several sites including Brumby Point, along Diggers Hole Spur Road, near Brumby Rocks and above the Buchan River Falls. Earlier collectors had regarded these as distinctive from *E. stellulata* and referred to them as *E. moorei* Maiden & Cambage (*D. Parkes*, 23.i.1984, MEL 1529442), *E.* aff. *stellulata* (*Molyneux*, 3.v.1991, MEL 227622) or *E. stellulata* 'mallee form' (*J.H. Willis. & K.C. Rogers*, 14.xi.1964, MEL 704360 and *A.M. Lyne 1195*, 25.iv.1993, MEL 717800). Nicolle (2006) regarded the Brumby Point and Diggers Hole Spur mallees as a distinct species and suggested an affinity with *E. moorei* Maiden & Cambage. Whilst we concur that these

Table 1. Morphological characters for River Peppermints

Character	*Eucalyptus elata*	*Eucalyptus ornans*
Habit	medium to tall tree, 10-45 m tall, rarely a mallee	mallee to 10 m tall
Branch orientation	Pendulous	semi-erect
Bark	stocking of finely fissued, compact bark present on lower trunk	smooth throughout
Juvenile leaves		
Colour and lustre	green above, pale green below, slightly lustrous	blue-green above, whitish below, dull
Shape	narrowly lanceolate	narrowly lanceolate
Size	60-120 mm long, 10-25 mm wide	50-80 mm long, 7-12 mm wide
Intermediate leaf colour	green	sub-glaucous
Adult leaves		
Colour	lustrous, green	sub-lustrous, blue-green
Shape	narrowly lanceolate	narrowly lanceolate
Size	80-170 mm long, 8-15 mm wide	60-110 mm long, 8-12 mm wide
Petiole length	10-15 mm	6-11 mm
Canopy composition	entirely of adult leaves	a mixture of adult leaves and intermediate leaves
Buds per umbel	Variable between populations, 17-40+	17-21
Peduncle length	5-10 mm	6-12 mm
Buds		
Shape	Clavate	fusiform
Size	4-5 mm long, 2-3 mm wide	c. 4 mm long, 2 mm wide
Operculum shape	hemispherical or beaked	conical
Pedicel length	2-6 mm	6-10 mm
Fruits		
Size	4-6 mm long, 4-6 mm diameter	c. 4 mm long, c. 4 mm diameter
Shape	slightly cupular to globular-truncate	slightly cupular to globular-truncate

mallees represent an unnamed species, we consider them more closely related to *E. stellulata* than *E. moorei*. Nicolle also regarded a population of stunted trees on the upper slopes of Mount Useful as conspecific with the Brumby Point mallees. We do not accept this diagnosis and regard the Mount Useful population as a stunted form of *E. stellulata*.

The series *Longitudinales* is a narrowly defined complex comprising eight taxa (*E. stellulata*, *E. mitchelliana* Cambage, *E. moorei*, *E. latiuscula* (Blakely) L.A.S.Johnson & K.D.Hill, *E. serpentinicola* L.A.S.Johnson & Blaxell, *E. copulans* L.A.S.Johnson & K.D.Hill, *E. dissita* K.D.Hill and the species treated here, *E. forresterae* Molyneux & Rule, all of which have similar buds and fruits but differ in habit, bark and leaf morphology. *Eucalyptus latiuscula*, *E. dissita* and *E. serpentinicola* are closely related to *E. moorei*. In fact, the first two are regarded as being synonymous with *E. moorei* by Brooker and Kleinig (1999), while *E. serpentinicola* was renamed *E. moorei* subsp. *serpentinicola* Brooker & Kleinig in that text. We accept that both *E. latiuscula* and *E. dissita* are morphologically close to *E. moorei* and have not included them in the key. We also accept that *E. serpentinicola* is best regarded as a subspecies of *E. moorei*. With regard to *E. latiuscula*, Hill (2002) considered that it occurred in Victoria. As far as we are aware, the only Victorian eucalypt which could be mistaken for *E. latiuscula* is *E. forresterae*.

Taxonomy

Eucalyptus forresterae Molyneux & Rule sp. nov.

Eucalypto stellulata *affinis habitu 'malleeformibus' fruticosis, cortice omnino laevis, foliis juvenilibus hebetibuscineraceis minoribus, foliis adultis glaucescentibus nitentibus minoribus, petiolis brevioribus et fructibus minoribus differt.*

***Type*:** Victoria. 6.2 km along Brumby Point Track from Diggers Hole Spur Road, 37°03'30" S 148°04'33" E, 15.xi.2008, *W. Molyneux & S. Forrester s.n.*, (MEL 2828603, AD, CANB, HO, NSW).

Dwarf, whipstick, shrubby *mallees*, 2–5 m tall. *Bark* smooth throughout, off-white or light grey, shedding to green in summer; old bark decorticating in brown to grey sheets and strips. *Seedling stems* round in cross-section; prominently raised glands present, persisting throughout the seedling stage. *Seedling leaves* decussate, ovate, discolorous. *Juvenile leaves* cordate or orbicular, opposite, sessile, amplexicaul, horizontally-oriented, discolorous, dull, glaucous for numerous pairs, 20–40 mm long, 20–40 mm wide; apex mucronate; nodes extremely crowded. *Intermediate leaves* ovate, sessile or shortly petiolate, opposite, sub-opposite or disjunct, slightly discolorous, blue-green. *Adult leaves* narrowly ovate or lanceolate, disjunct, shortly petiolate, acuminate or apiculate, uncinate, coriaceous, concolorous, sub-lustrous or lustrous, olive-green or blue-green, 40–60 mm long, 12–20 mm wide, 0.4–0.55 mm thick; petioles 2–6 mm long; leaf base rounded; lateral veins prominent, parallel to mid-vein, forming a prominent tri-veined pattern; intramarginal veins faint or obscure, 1–2 mm from margin, reticulation sparse; oil glands numerous, moderately sized, regular, island. *Inflorescences* simple or sometimes paired, axillary, 11–21-flowered; buds forming a small, stellate cluster; peduncles 1–3 mm long in the bud stage, sometimes absent in the fruiting stage. *Floral buds* horn-shaped, sessile, unscarred, orange to burgundy when mature, 4–6 mm long, c. 2 mm diameter; operculum single, horn-shaped, c. as long as hypanthium; stamens erect, all fertile; filaments white; flowering period irregular over the summer months; anthers versatile, sub-basifixed, reniform, dehiscing through diagonal slits; ovules in 2 vertical rows. *Fruits* cupular or globose-truncate, sessile, 2.5–4 mm long, 2.5–3.5 mm wide; disc slightly descending; valves enclosed; locules 3. *Fertile seeds* irregularly cuboid or pyramidal, blackish; hilum terminal (Fig 3).

Distribution and habitat: *Eucalyptus forresterae* is only known from four sites in the Alpine National Park in East Gippsland, Victoria. Three sites are at elevations of 1399–1450 m, with the type locality on the Brumby Point Track separated by c. 5 km from the second site (c. 1 km north of Diggers Hole Spur Road above Diggers Hole Creek) to the south-west, and c. 10 km from the third site on the Nunniong Road to the west. The fourth site, located on a rocky hill above the falls on the Upper Buchan River at Native Dog Flat, is c. 16 km NNE of the type locality at an elevation of 1200 m. Approximately 30 m below this rocky site, *E. stellulata* grows as a large tree beside and in the vicinity of the Buchan River in moister conditions. At Horse Flat (c.

1.5 km south of *E. forresterae* on the Nunniong Road), and at Blue Shirt Creek. (c. 11.5 km further south), stunted forms of *E. stellulata* occur in moist to wet conditions. By contrast, the four known populations of *E. forresterae* are restricted to high rocky or well-drained elevated sites (Fig. 2).

Additional specimens examined: **VICTORIA**. Above Buchan Falls, 36°54'16" S 148°05'13" E, 3.v.1991, *W.M. Molyneux s.n.* (MEL 227622); 1 km N of Diggers Hole Spur Road on western slope above Diggers Hole Creek, 37°05'04" S 148°01'03" E, 12.xi.2009, *W.M. Molyneux & S. Forrester s.n.* (MEL); Nunniong Road, c. 4.5 km S of Brumby Rocks, 2.5 km N of Jam Tin Track turnoff, 37°03'42" S 147°56'23" E, 12.xi.2009, *W.M. Molyneux & S. Forrester s.n.* (MEL).

Associated species: *Eucalyptus* sp. aff. *dives* Schauer, *E. elaeophloia* Chappill, Crisp & Prober, *E. glaucescens* Maiden & Blakely, *E. kybeanensis* Maiden & Cambage, *E. mannifera* Mudie, *E. pauciflora* Sieber ex Sprengel subsp. *niphophila* (Maiden & Blakely) L.A.S.Johnson & Blaxell, *E. perriniana* F.Muell. ex Rodway, *E. rubida* H.Deane & Maiden, *E. viminalis* Labill. subsp. *viminalis* and *Hakea asperma* Molyneux & Forrester have been

Figure 3. *Eucalyptus forresterae* a) regenerating mallee at Brumby Point post 2003 fires (Molyneux, 15/11/08); b) buds and adult leaves at Brumby Point (Molyneux, 15/11/08); c) fruits from type locality (Rule, 6/2/10)

observed growing in association with the new species. A form of *E. dalrympleana* Maiden also occurs in the general vicinity of the new species. The only known site where *E. forresterae* and *E. stellulata* occur in close proximity is along the Buchan River valley near Native Dog Flat where the former occurs on the ridge overlooking the Buchan River Falls and the latter occurs along the valley floor.

Etymology: The specific epithet honours Sue Forrester of Dixons Creek, co-collector of the type specimen and major contributor to field survey work and progeny trials.

Recommended English name: Brumby Sallee.

Conservation status: The new species is restricted to four known isolated populations with an estimated extent of occurrence of approximately 100 km^2 and an estimated area of occupancy (AO) of 6.5 ha based on the estimated AOs of the four populations (2.5 ha, 2.5 ha, 1.0 ha and 0.5 ha respectively). The species is also assessed as naturally severely fragmented at the landscape scale on account of the small disjunct populations and limited seed dispersal capacity. The species is also arguably subject to continuing decline in the quality of its habitat as a consequence of the inferred and projected impact of climatic drying and elevated temperature thresholds on the recruitment potential of almost all montane to subalpine Victorian eucalypts including *E. stellulata* and, by inference, *E. forresterae* (Nitschke & Hickey 2007). The species is therefore assessed as critically endangered under the IUCN Red List categories and criteria (IUCN 2001) with a threat code of CR B1ab(iii)+2ab(iii).

Discussion: *Eucalyptus forresterae* is distinguished within the Series *Longitudinales* by the following combination of features: its dwarf mallee habit, smooth bark, crowded, small orbicular or cordate, glaucous juvenile leaves, small ovate, shortly petiolate, bluish adult leaves with parallel venation and its relatively dense canopy. We regard *E. stellulata* as its nearest relative on the basis of the adult leaves of both species having similar venation patterns, both having a sparsely reticulate network dominated by a mid-vein and two conspicuous parallel lateral veins arising at the leaf base. However, *E. forresterae* differs from *E. stellulata* by the latter species being a relatively large, umbrageous tree (to 20 m tall and 15 m wide) and having a substantial stocking of blackish, cracking compact bark with smooth olive-green bark above, larger, relatively sparse, greenish juvenile leaves (to 70 mm long and 70 mm wide), lustrous, green, semi-pendulous adult leaves with relatively long petioles, generally larger buds and fruits and an open canopy in contrast to the extremely compact and congested canopy of *E. forresterae* (Table 2).

We agree with Nicolle (2006) that *E. forresterae* is related to *E. moorei* but believe that *E. stellulata* is its closest relative primarily on the basis of the venation patterns of the adult leaves. The adult leaves of both *E. forresterae* and *E. stellulata* are tri-veined, that is, having lateral veins arising from the base of the mid-vein and running unbroken between it and the intramarginal veins for the length of the leaf. This contrasts to the adult leaves of *E. moorei*, which exhibit a form of parallel venation consisting of a dominant mid-vein and visible, somewhat remote intramarginal veins that are connected by extremely faint, sparse, markedly acute lateral veins. Plants of *E. forresterae* raised to maturity in cultivation in metropolitan Melbourne and at Dixons Creek in the Yarra Valley retain diagnostic vegetative features of the species, notably the smooth bark, dwarf mallee habit, glaucous juvenile leaves and small, ovate, crowded, rigid adult leaves.

Molyneux and Forrester (2008) postulate that three highly restricted *Acacia* species endemic to the Wombargo Range evolved their dwarf habit, reduced organ size and strictly vegetative reproductive strategies through adaptation to the late Quaternary permafrosts associated with a glacial event on the Kosciuszko Plateau. Hills (1975) states that these conditions would have extended to the Wombargo and Cobberas Ranges, the southern end of which is only c. 5 km from the northerly population of *E. forresterae*. As the main populations of *E. forresterae* occur c. 16–22 km further south, it is reasonable to suggest that the effect of permafrost events extended to the Nunniong district.

Hakea asperma, a dwarfed infecund shrub persisting by ramets, is notably sympatric with *E. forresterae* above Native Dog Falls, providing a further illustration of the synchronous adaptation by these local endemics to permafrost events (Molyneux and Forrester 2009).

As climate warmed during the Holocene (McKenzie 1997), vegetation succession involved the upslope migration of a suite of *Eucalyptus*, *Acacia* and associated lower elevation species which progressively replaced

the cold-adapted montane flora of the region with some limited persistence of taxa which managed to adapt to the climatic warming of the late Quaternary.

These upslope migrations resulted in some interesting associations with, and adaptations by, *E. forresterae* populations. While the eucalypts sympatric with *E. forresterae* at the type locality are of mallee habit, the other three populations are variously sympatric with tall tree forms of *E. dalrympleana*, *E. pauciflora*, *E. perriniana*, *E. rubida* and *E. viminalis*, and with *E. stellulata* in the general vicinity.

At the Diggers Hole site stunted but not strictly mallee-form stands of *E. pauciflora* and *E. perriniana* 2–2.5 m tall are sympatric with the southernmost known stand of *E. forresterae*, while c. 50 m further south 15–25 m tall forest trees of the two associated species occur. It could well be that the early colonising stands of *E. pauciflora* and *E. perriniana* encountered much lower temperatures at the conclusion of the permafrost events and underwent adaptive modification during the Holocene warming while later immigrants retained their characteristic tree form.

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Table 2. Morphological and habitat characters for two Victorian species of the series *Longitudinales*.

Character	*Eucalyptus stellulata*	*Eucalyptus forresterae*
Habitat	sites of poor drainage	well-drained, rocky ridge-tops
Habit	medium to large tree to 20 m tall, single or multi-stemmed	whipstick or shrubby mallee to 4 m tall
Bark	blackish, compact basal stocking usually present, olive-green above	smooth, greyish throughout, shedding to olive green in summer; no basal stocking
Juvenile leaves		
Size	40-70 mm long, 40-70 mm wide	20-40 mm long, 20-40 mm wide
Shape	cordate or orbicular	cordate or orbicular
Colour	dull, green or blue-green	blue-grey
Adult leaves		
Size	50-100 mm long, 12-25 mm wide	40-60 mm long, 12-20 mm wide
Shape	Lanceolate or ovate	narrowly ovate or lanceolate
Colour and lustre	olive-green or green, lustrous	olive-green or blue-green, sub-lustrous
Venation	parallel (tri-veined)	parallel (tri-veined)
Petiole length	3-10 mm	2-6 mm
Buds per umbel	11-15	11-21
Peduncle length	3-6 mm	1-3 mm
Buds		
Shape	horn-shaped	horn-shaped
Length	4-7 mm	4-6 mm
Fruits		
Size	4-6 mm diameter	2.5-4 mm diameter
Shape	slightly cupular to globular-truncate	slightly cupular to globular-truncate

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Arthonia banksiae (lichenised Ascomycota) and its synonyms

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Abstract

Arthonia banksiae, a widespread lichen known from the central and eastern Victorian coast, is lectotypified, described, and illustrated from modern collections. *Mycoporellum microspermum* and *Asteroporum rimale*, the latter name previously shrouded in some confusion, are synonyms of *A. banksiae*; the latter species is also lectotypified. *Arthonio microspermo* has been recorded for Australia in error and should be deleted from the Australian lichen census.

Keywords: *Arthonio*, taxonomy, lichenised Ascomycota.

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Introduction

One of the key problems confounding researchers of incompletely documented lichen floras such as Australia's concerns the existence of names which have yet to be ascribed to any recently-collected and identified specimens, and for which there are no comprehensive descriptions beyond century-old, often ambiguous diagnoses. Such names persist in checklists but there is usually little notion of what entity they actually represent. This is particularly the case with crustose lichens, which may have been described within genera that today are either not in use, or whose delimitation has been tightened; the 'dustbin' genera such as *Lecidea*, *Bacidia* and *Catillaria* are typical of the latter. To resolve the identity of such taxa requires a study of types or authentic material, which are almost inevitably in foreign herbaria, sometimes in poor condition or cannot be traced.

Three such lichens, which have been cited in all Australian checklists since that of Weber and Wetmore (1972), are *Arthonia banksiae* Müll. Arg., *Mycoporellum microspermum* Müll. Arg. and *Asteroporum rimale* Müll. Arg. The first author first encountered and examined authentic material of *A. rimale*, collected by the 19th Century lichenologist, F.R.M. Wilson, in London's Natural History Museum in 1994. Almost fifteen years later, very rich material of what was clearly the same taxon was collected by the second author in Victoria. In the meantime, following a revision of the Pyrenulaceae for Australia by Aptroot (2009), *A. rimale* was recognised as a dubious name and removed from the Australian lichen checklist (McCarthy 2010). The availability of material sufficient for thorough anatomical examination inspired a more detailed reappraisal of this taxon. In the process, we unearthed several synonyms for this species, enabling a clarification of its rather convoluted taxonomy.

Material and methods

The study is based on specimens housed in the Natural History Museum (BM), the National Herbarium of Victoria (MEL), the Conservatoire et Jardin botaniques (G) and the Tasmanian Herbarium (HO).

The description given is based on hand-cut sections of the thallus and ascomata, mounted in water, 15% KOH, Lugols Iodine, ammoniacal

erythrosin or Lactophenol Cotton Blue, and examined with high-power, light microscopy. Dimensions of asci and ascospores are based on 25 and 100 observations respectively; the latter are presented in the format: smallest measurement–*mean*–largest measurement.

General discussion

Müller (1884) described the genus *Asteroporum* to accommodate a calciphilous, saxicolous species from Palestine (*A. perminimum* Müll.Arg.). His description suggests a pyrenocarpous taxon with perithecioid, subglobose ascomata, simple paraphyses and hyaline, trans-septate ascospores. Therein he discussed the affinities of his new genus to *Mycoporum* Flot. ex Nyl. and *Mycoporellum* Müll. Arg. The corticolous *Asteroporum rimale* from Australia (Müller 1895) and *A. deformatum* Zahlbr. from decorticated eucalypts in Java (Zahlbruckner 1928) were subsequently newly described, whereas Zahlbruckner (1926) transferred to the genus some species that had initially been described by Müller in *Astrotrema* Müll. Arg. Since these early papers, the name *Asteroporum* has not been applied, and today the genus is ascribed with some uncertainty to the Pyrenulales (Lumbsch and Huhndorf 2007), a position consistent with the salient characters indicated in the original description.

Even the briefest examination of specimens labelled as *A. rimale* indicates that this species has no connection with the Pyrenulales, as it lacks perithecia and has indistinct, anastomosing paraphyses. Rather, it has well-developed ascomata lacking a well developed excipulum and globose asci of the *Arthonia*-type (Grube and Matzer 1997; Grube 1998), characters indicative of the genus *Arthonia* Ach. With this in mind, our investigation was extended into *Arthonia*, a genus that, in Australia, is rich in taxa and for which numerous described names (often of uncertain application) exist. The earlier name *Arthonia banksiae* Müll. Arg. was found to be appropriate for this species.

The nomenclatural history of these taxa is quite confusing. Müller (1893) described *A. banksiae* from two specimens, numbered 885 '*pr.p.*' and 1585, sent to him by the Australian lichenologist F.R.M. Wilson (Fig. 1). These specimens are housed at the Conservatoire et Jardin botaniques in Geneva (G), and have been located and studied. They display all the salient features of the species, especially its curious, lirella-like ascomata. Specimen 885 appears to consist

Figure 1. Lectatype *af Arthonia banksiae* Müll. Arg. (G).

Figure 2. Isolectatype *af Asteraparum rimale* Müll. Arg. (= *Arthania banksiae*) (MEL 5810).

of two separate parts glued together, with the number '885' attached to a specimen and card also bearing the inscription 'Wilson n. 175'. Two years later, Müller (1895) described *Asteroporum rimale*, also basing it on Wilson's no. 885 collection in G, '*pr.p.*', albeit a different fragment of bark in a different packet, as well as on two specimens from New South Wales collected by Charles Knight. Wilson's no. 885 is a rich collection with duplicates housed in the National Herbarium of Victoria (MEL) (Fig. 2) and the National Herbarium of New South Wales (NSW). We have not located or studied the Knight specimens, but Müller (1895) referred to them being originally identified by the collector as *Mycoporum*, a genus of pyrenocarpous lichens with no relationship to *Arthonia*. In the same paper and on the basis of a further specimen, also numbered '885 *pr.p*', Müller (1895) then described *Mycoporellum microspermum*. This specimen had been previously cited as *Arthonia microsperma* (Fée) Nyl. in an earlier paper (Müller 1893: p. 59). This record is the source of the inclusion of *A. microsperma* in Australian lichen lists. When Müller changed his mind and described the same specimen as *Mycoporellum microspermum*, on the label he just wrote the new determination over the old one. The type of *Mycoporellum microspermum* has rounded, typically arthonioid ascomata but, on the basis of anatomy, it is conspecific with *Arthonia banksiae*.

Curiously, the description of *A. rimale* makes no reference to *A. banksiae*, even though it comments on other related or similar species. It is impossible to unravel the reasons for this convoluted taxonomy, but the key issue is that *Arthonia banksiae* is a valid name for a conspicuous species in the Victorian flora, and that *Asteroporum rimale* and *Mycoporellum microspermum* are its synonyms. To avoid the confusion surrounding Wilson's specimen no. 885, it is his no. 1585 that is selected as the lectotype of *A. banksiae*. A detailed description of the species follows.

Taxonomy

Arthonia banksiae Müll. Arg., *Bull. Herb. Boissier* 1: 59 (1893)

Type: "Corticola ad ramos *Banksiae serratae*, Mordialloc: Wilson n. 885, Lakes Entrance: Wilson 1585, et prope Cheltenham: Wilson n. 885 pr.p."; lectotype, here designated: Lakes Entrance, Victoria, on *Banksia serrata*, 1892, *Rev. F.R.M. Wilson* 1585, G!; syntype: Mordialloc, Victoria, on *Banksia serrata*, 1892, *F.R.M. Wilson* 885, G!.

Asteroporum rimale Müll. Arg., *Bull. Herb. Boissier* 3: 324 (1895)

Type: "Corticola, New South-Wales: Knight n. 6 et 26 ... et in prov. Victoria ad Cheltenham: Rev. Wilson n. 885 pr.p."; lectotype, here designated: Cheltenham, near the sea, Victoria, *F.R.M. Wilson* 885 *p.p.*, G!; isolectotypes, MEL!, NSW.

Mycoporellum microspermum Müll. Arg., *Bull. Herb. Boissier* 3: 325 (1895)

Type: "Corticola ad truncos *Banksiae* ad Cheltenham prope mare in prov. Victoria: Wilson n. 885 pr.p."; holotype: Cheltenham, near the sea, Victoria, *F.R.M. Wilson* 885 *p.p.*, G!; isotype: "on *Banksia*. Cheltenham, Victoria. *F.R.M.Wilson* s.n.", MEL!.

Thallus crustose, smooth, pale pink-brown to cream, not delimited, ecorticate, very thin, mostly to 10–20 µm, but barely differentiated from underlying bark cells, apparently not lichenised; photobiont absent but occasionally a few coccoid green cells present. *Ascomata* very variable, irregularly roundish, most commonly elongate, curved, flexuose or stellate, 0.3–1.5 mm long, 0.2–0.4 mm wide, blackish brown to black, often with a thin, darker margin and appearing lirelliform, in section 40–60 µm thick and with a well-developed, lateral, exciple-like zone, 10–20 µm thick, dull olive-green, intensifying in K, composed of conglutinated pigmented hyphae 3–5 µm wide. *Hypothecium* colourless, poorly differentiated from the hymenium, c. 10–20 µm thick. *Hymenium* 30–50 µm thick, mainly colourless but diffusely olive-greenish in the upper part or with the pigment in a discrete layer and ± continuous with the exciple, I+ red, K/I+ blue; paraphysoids highly branched and anastomosing, rather knobbly and of uneven thickness, 1.5–2.5(–3) µm thick, with apices usually pigmented greyish green; *asci* 25–36 × 17–25 µm, of the *Arthonia*-type: broadly ovate to globose, mostly with a short 'foot' at the base and a well-developed tholus I-, KI-, lacking or at best with a barely discernible, faintly amyloid ring-structure; apex of ascoplasm variable with age,

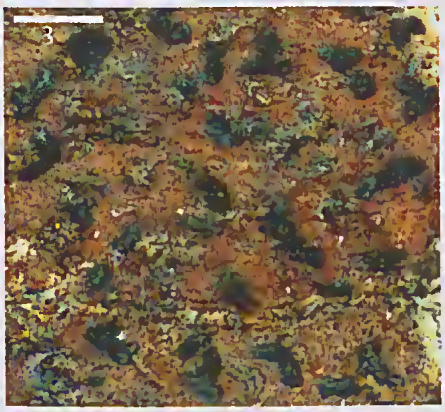
concave, rounded or extending in a beak-like ocular chamber. *Ascospores* colourless, 1-septate, 10–*12.8*–15 × 4–*5.3*–6 µm, broadly ellipsoid, sometimes slightly constricted at the septum. *Pycnidia* immersed, speck-like, black, resembling incipient ascomata, in section pigmented olive-green; conidia rod-shaped, 6–7.5 × 0.8 µm. *Chemistry* nil. Figs 3–4.

Additional specimens examined: **Australia. Victoria:** Queenscliff, 13 April 1896, *F.R.M. Wilson s.n.* (BM); Beaumaris, foreshore reserve, 37°59'08"S 145°01'28"E, 1m altitude, 6 July 2008, *V. Stajsic 4617* (HO, MEL2324321); Seaford, foreshore reserve, 38°06'21"S 145°07'32"E, 15 January 2009, *V. Stajsic 4926* (HO, MEL2327882); Seaford, Kananook Creek Reserve, 38°06'08"S 145°07'40"E, 15 January 2009, *V. Stajsic 4934* (HO, MEL2327905); Walkerville Coastal Reserve, 38°51'22"S 145°59'50"E, 16 March 2009, *V. Stajsic 5139* (HO, MEL2334233); Walkerville North, Walkerville Coastal Reserve, 38°50'12"S 146°00'14"E, 19 March 2009, *V. Stajsic 5128* (HO, MEL2334222); Croajingolong National Park, mouth of Shipwreck Creek, 37°38'54"S 149°41'54"E, 24 July 2009, *V. Stajsic 5455* (HO, MEL2342601); Cape Conran Coastal Park, 37°47'57"S 148°41'43"E, 25 July 2009, *V. Stajsic 5458* (HO, MEL2342604).

Also examined: Arthonia excipienda: **United Kingdom.** Mull, 1 mile east of Achronich, 11 May 1968, *P.W. James* (BM). ***Arthonia microsperma***: ad corticem *Sonplandia trifoliata*, *Fée 266* (G).

Distribution and ecology: *Arthonia banksiae* is currently known only from Victoria, where it is widespread along the coastline from Queenscliff on the Bellarine Peninsula to Shipwreck Creek in Croajingolong National Park in the far eastern part of the State (Fig. 5). It is a corticolous species, and has only been observed growing on *Banksia integrifolia* L.f. subsp. *integrifolia*, sometimes forming extensive patches on the younger (i.e. several years old) branchlets that have not developed the rough bark typical of larger branches of this tree.

Although the notes on F.R.M. Wilson's collections from Cheltenham (a south-eastern suburb of Melbourne, Victoria) indicate that they were collected from the bark of *B. serrata* L.f., it is more likely that their host was *B. integrifolia*: this tree is indigenous to the Cheltenham area, and supports *Arthonia banksiae* today. The same is true for Mordialloc, a south-eastern suburb of Melbourne. In Victoria, *Banksia serrata* is confined to the east of Waratah Bay. Thus it is possible that Wilson's specimen from Lakes Entrance is from *B. serrata* as stated, although the area is within the range of *B. integrifolia* as well. However, limited survey of *B. serrata* in the field (for example, at Holey Plains and several sites in East Gippsland) did not reveal any *Arthonia banksiae* on this host. It remains to be seen whether *A. banksiae* also occurs on *Banksia integrifolia* subsp. *compar* (R.Br.)K.R.Thiele (coastal Queensland, between Proserpine and Brisbane), on subsp. *monticola* K.R.Thiele (New South Wales, between New England National Park and Blue Mountains), or on the related species *B. saxicola* AS.George (Victoria: Grampians, and Wilson's Promontory). It has also been searched for in south-eastern Tasmania, Kangaroo Island and in Victoria on *Banksia marginata* Cav., without success.



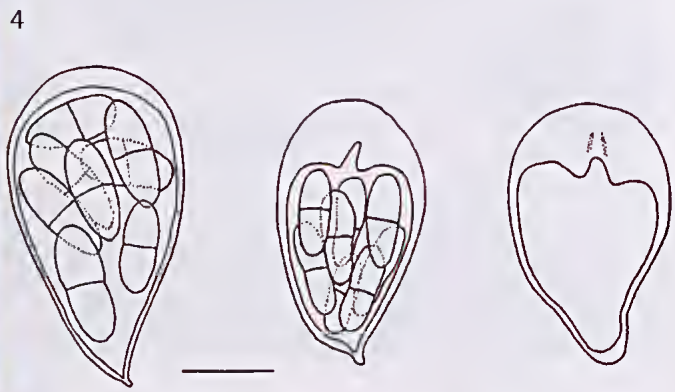


Figure 3. Habit of *Arthonia banksiae*, showing elongate, lirella-like ascomata (MEL 5810). Scale = 500 µm.

Figure 4. Asci and ascospores of *Arthonia banksiae* (*Stajsic* 4617). Note the faint amyloid ring in the youngest ascus (right). Scale = 20 µm.

Given the broad distribution of *A. banksiae* in Victoria, and its known host preference (which is distributed from coastal south-east Queensland to King and Flinders Islands north of the main island of Tasmania), it is likely that its distribution will prove to be more extensive than currently known. It is often a common species at the sites where it occurs, and is not considered to be under any threat.

Remarks: This is a very conspicuous species, characterised by the dull cream or pinkish-tinged thallus, speckled with numerous black ascomata. The shape of the ascomata is highly variable, and whereas some are of a roundish, typically arthonioid form, stellate or elongate ones are invariably present also. The latter are distinctive but enigmatic in that the central part of the disc is often slightly abraded, whereas the margins remain intact, conveying the appearance of the exciple of lirellae such as seen in species of *Opegrapha* Ach. When dry, this 'exciple' is black and concolorous with the rest of the surface of the ascoma, but when moist, it remains black whereas the inner, 'disc' becomes a paler brown-black, accentuating the lirella-like appearance. Müller certainly noted this in his original description of *A. banksiae*, and it was perhaps this feature that subsequently prompted him to coin the epithet *'rimale'*. In section, the structure differs starkly from the true exciple of *Opegrapha*, which is opaque, encloses the hymenium laterally and usually extends continuously beneath the hypothecium; *Opegrapha* also has different asci.

Arthonia banksiae is probably related to the widespread *A. dispersa* (Schrad.) Nyl., a relationship also noted by Müller (1893), which also has a non-lichenised thallus and 1-septate ascospores of a very similar size. What makes *A. banksiae* distinctive is the presence of the rudimentary but nevertheless conspicuous 'exciple' bordering the ascomata. Thus its closest relative is perhaps the Northern Hemisphere's *A. excipienda* (Nyl.) Leight., which has almost identical ascomata with a similar exciple. The significance of this structure, and how it underpins the differences between *A. dispersa* and *A. excipienda* (and thereby *A. banksiae*) is discussed in detail by Coppins (1989).

Arthonia banksiae and *A. excipienda* differ superficially, with the former being more coarse and robust, but this can possibly be attributed to habitat differences, with the latter occurring mainly on thin, young twigs with smooth bark, whereas the former is found mostly on older branches. Critically, *A. excipienda* differs further in having somewhat larger ascospores, 14–20 × 5–8 µm (this study).

In his original description of *A. banksiae*, Müller also noted similarities to the tropical species, *A. microsperma*, from which his new species differed by

Figure 5. Distribution of *Arthonia banksiae*.

having "more linear apothecia and larger spores" (Müller Arg. 1893). However, in the same paper, he also records *A. microsperma* from Victoria. We have examined the type of *A. microsperma* (from G) and can confirm Müller's observations: it has typically arthonioid, rounded ascomata and 1-septate ascospores, 7–10 × 4–4.5 µm. However, the Australian specimen under this name is *A. banksiae*, albeit a youngish individual with rounded rather than elongate ascomata. The smaller ascospores reported by Müller were not observed and these may perhaps be attributable to the immaturity of the specimen. Consequently, *A. microsperma* can be deleted from the Australian lichen census.

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An etymology of Australian bryophyte genera. 2 — Mosses

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Introduction

'The question is,' said Alice, 'whether you can make words mean so many different things.'

'The question is,' said Humpty Dumpty, 'which is to be master—that's all.'

— Lewis Carroll, *Through the Looking Glass*, chapter 6

Most of the names of bryophyte genera are derived from Greek and Latin stems but also often from personal names, some of which have been obscured by the passage of time. This paper sets out as much as can be established about the true etymology of the names of all moss genera accepted for Australia (Flora of Australia 2006), and complements a similar paper on Australian liverwort and hornwort genera (Meagher 2008). For the sake of regional completeness I have also included moss genera known from New Zealand as listed by Fife (1995).

The etymologies of generic and species names are often included in floras, but they are rarely taken from the original sources and are very often wrong. Worse still are the attempts to 'translate' names into English, on the assumption that this will make things easier or more interesting for the beleaguered reader struggling with classical languages. Samuel Gray was probably the first major culprit in this regard, when he coined such idiocies as Stinking Naked-foot for *Gymnopus graveolens*, Gelatinous Hedgehog-stool for *Steccherinum ochraceum*, Fireproof Spring-moss for *Fontinalis antipyretica* and Mis-shapen Elisa for *Elisa distorta* (Gray 1821a), and replaced evocative and often instructive names with lifeless translations, such as Biting Stone-crop instead of Jack of the Buttery, and Odorous Spiraea instead of Meadow Sweet (Gray 1821b). In Gray's defence, he may have been encouraged by the efforts of 'A Botanical Society at Litchfield' in translating Linnaeus (Linné 1783). Johnson (1980) continued the tradition when she presented the world with more than 130 new 'English names based on the original scientific names' for mosses, including Mueller's Horizontal Tooth Moss for *Syrrhopodon muelleri*, Dubious Bladder Moss for *Vesicularia dubyana* and Uncovered Nipple Moss for *Taxithelium instratum*.

Unfortunately it is not always easy to understand the original intentions of authors of the names included here, particularly William

Abstract

The meanings of the names of the moss genera presently known from Australia are elucidated, with supporting evidence where possible from the authors of the names. Genera known from New Zealand but not Australia are included for regional completeness.

Keywords: cryptogam, Australia, New Zealand

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Mitten, who named many moss genera but never explained his names directly. On the other hand, other major authors such as Samuel–Elisée von Bridel(-Brideri), Carl Müller (at Halle) and Wilhelm Schimper gave the etymologies for most of their names. Often the choice of name had little if anything to do with a feature that distinguished the genus from others, but merely related to some feature from which a convenient name could be constructed. Furthermore, the rationale for distinguishing a genus from others was very often at odds with modern concepts, and must be viewed only in an historical rather than systematic context.

Where possible I have gone to the original publication to determine the author's intention. If that has not been possible I have tried to locate the author's explanation in a later work, or an explanation by another bryologist in a contemporaneous publication. The *International Code of Botanical Nomenclature* (McNeill *et al.* 2006) fixes the earliest publication of valid names for mosses as the first edition of Johann Hedwig's *Species Muscorum Frondosorum* (Hedwig 1801), with the exception of *Sphagnum*, which is attributed to Linnaeus. But many of the genera attributed to Hedwig (1801) in the following list had already been coined by other authors. In those cases I have gone if possible to the original publication of the name.

De Vries (1951) and De Vries and Jacolev (1978) proved useful in deciphering unusual terms in German and French. Although I have not seen it, *Lexikon deutschsprachiger Bryologen* (Frahm & Eggers 2001) must also be very useful for translating German bryological texts. For simplicity the word stems are given here in anglicised Greek rather than classical Greek, and the aspirated *h* sound is included in the spelling of the stem where necessary, as in *hygros* and *rhodon*.

For Latin stems I have relied on Lewis (1891) and Marchant and Charles (1952), and for Greek stems I have relied on Bagster (1870) and Morwood and Taylor (2002). The older two of these references are particularly useful for understanding the intentions of earlier authors. Quotations are as in the original text, including italicisation and capitalisation. I have chosen not to translate quotations from other languages because to do so would introduce long pages of endnotes, and because I would like to encourage readers to make their own translations. Author abbreviations follow Brummit and Powell (1992) and IPNI (2008).

Etymologies

Acanthorrhynchium M.Fleisch. 1923 — *akanth*os (spine) + *rrhynch*os (bill, beak), referring to the long beak of the operculum. The name was a replacement for *Acanthodium* Mitt. 1868, which Max Fleischer pointed out was already in use for a genus of vascular plants, *Acanthodium* Delile 1813 (Fleischer 1923: 1331).

Acaulon Müll.Hal. 1847 — *a–* (without) + *kaulon* (stalk), alluding to the very short, seemingly stemless plants: 'Nomen ob humilitatem congenerum magnam impositum.' (Müller 1848: 21).

Achrophyllum Vitt & Crosby 1972 — *achroma* (colourless) + *phyllon* (leaf). 'The name *Achrophyllum* refers to the almost colourless nature of the leaves of the type species.' (Vitt & Crosby 1972: 174). *Achrophyllum* replaced Bridel's illegitimate name *Pterygophyllum*.

Acrocladium Mitt. 1869 — *akros* (pointed; at the tip or top) + *klados* (stem, branch), probably alluding to the cuspidate and imbricate leaves at the tips of the branches — 'foliis...in ramorum apicibus cuspidatum imbricatis' (Mitten 1869: 531). The name might also be a clever double-meaning, referring also to the occasional rooting of the tips of the branches in *A. auriculatum* (Mont.) Mitt., which William Mitten stressed in his diagnosis and commentary: 'ramulis apicibus interdum descrescentibus radicantibus' (Mitten 1869: 532).

Acroporium Mitt. 1868 — *akros* (pointed; at the tip or top) + *poros* (perforation, passage, tube), undoubtedly referring to the inrolling of the upper margins of the leaves: 'margine versus apicem involuta' and 'marginibus superne involutis integerrimis' (Mitten 1868: 183).

Aerobryopsis M.Fleisch. 1905 — genus *Aerobryum* + *opsis* (similar to), alluding to the similarity to that genus, some species of which were transferred by Fleischer to his new genus. *Aerobryum* comes from *aer* (air) + *bryon* (moss), referring to the typical habit of the plants, dangling in skeins from the branches of trees.

Aloina Kindb. 1882 — *Aloe* (a liliaceous genus) + *-ina* (resembling), referring to 'the fleshy nature of the leaves, which suggest those of an *Aloë*' (Crum & Anderson 1981). The name was first proposed by Carl Müller for a section of the genus *Barbula* and was conserved over the earlier *Aloidella* (De Not.) Venturi 1868 by the action of the Botanical Congress of 1930 (Delgadillo 1975: 246).

Amblystegium Schimp. 1853 — *amblys* (blunt) + *stegeon* (roof, covering), referring to the shape of the operculum: 'Operculum magnum tumido-conicum obtusum (unde nominis ratio, αμβλυς obtusus)' (Schimper 1860: 587).

Ambuchanania Seppelt & H.A.Crum 1999 — After Alex M. Buchanan, Tasmanian naturalist, who collected the type of the only member of the genus, *A. leucobryoides*, from Port Davey (Crum & Seppelt 1999: 29).

Amphidium Schimp. 1856 — A revised name based on *Amphoridium*, from *amphora* (urn), alluding to the shape of the capsule. The name *Amphoridium* was first published by A.B. Massalongo in 1853 for a genus of lichens, so Wilhelm Schimper republished his bryophyte genus as *Amphidium*. Schimper's name was subsequently conserved against *Amphidium* Nees 1819 (Magill 1993: 6).

Anacamptodon Brid. 1819 — *anakamptos* (bent back) + *odon* (tooth), alluding to the reflexed outer peristome teeth (Bridel 1827: 225), 'a feature made striking because of a suboral constriction of the capsule' (Crum & Anderson 1981).

Andreaea Hedw. 1801 — After Johann Gerhard Reinhard Andreä (1724–1793), chemist and court apothecary in Hannover. The name is attributed to Hedwig under the *Code* but was first coined by Johann Erhardt: 'Es ift diefer Menschenfreund der hiesige Apotheker, Herr J. G. R. Andreae, welcher durch seine gründliche Kenntnisse in allen Theilen der Naturgeschichte, und Bemühungen zur Ausbreitung nützlicher Wissenschaften einem jeden bekannt ist.' (Erhardt 1787: 16). Andreä's surname is often stated as Andreae, which is the Latinised form that he used in his profession and on which the genus name is based.

Anisothecium Mitt. 1869 — *anisos* (unequal, different) + *thekion* (little vessel, container). In Mitten's generic diagnosis and descriptions of species there is no indication of what this refers to (Mitten 1869: 39), but it is probably the difference in the capsules from those of *Dicranum*, from which *Anisothecium* was separated.

Anoectangium Schwägr. 1811 — *anoikto* (open) + *angion* (vessel), alluding to the lack of a peristome ('Peristomium nullum') (Schwägrichen 1811: 33). It seems Dixon (1954: 255) was not quite correct in suggesting that it referred to 'the wide-mouthed capsule in some species'. The name is conserved against *Anictangium* Hedw. 1801 (= *Hedwigia* P.Beauv.).

Anomobryum Schimp. 1860 — *anomos* (anomalous) + *bryon* (moss). Schimper's diagnosis suggests that he regarded his type species *Anomobryum julaceum* as anomalous when placed in *Bryum*, particularly because the cells in the upper leaf are hypnoid (i.e. long and narrow). 'Caracteribus supra expositis facile ab omnibus *Bryaeis* europaeis distinguitur' (Schimper 1860: 382).

Anomodon Hook. & Taylor 1818 — *anomos* (anomalous) + *odon* (tooth). William Hooker and Thomas Taylor erected the genus to separate two species from *Neckera*, because they believed that their ciliate inner peristome teeth arose from the teeth of the outer peristome, unlike 'the true *Neckerae*' (Hooker & Taylor 1818: 79). The genus stands despite this concept being shown to be false: 'In the older sense, the genus *Anomodon* includes various species which are now classified in other genera.' (Iwatsuki 1963).

Archidium Brid. 1826 — *archidion* (primitive), alluding to Bridel's view that these were the earliest of all mosses: 'huic generi totius muscorum gentis primordio impositum' (Bridel 1826–27: 747), a view apparently not shared by Carl Müller, who exclaimed 'ex auctoris ratione!' (Müller 1848: 13).

Arthrocormus Dozy & Molk. 1846 — *arthros* (jointed) + *cormos* (stem), alluding to the unusual jointed appearance of the branches: 'Ramificatione sua peculiari, foliorum dispositione exacte trifaria et organorum plurimorum forma trigona hocce

genus ab aliis facile distinguitur...' (Dozy & Molkenboer 1846: 76).

Astomum Hampe 1837 — *a* (without) + *stoma* (opening), alluding to the cleistocarpous capsule. Hampe's three-word diagnosis ('Phasca angustifolia perennia') (Hampe 1837: 285) — surely the shortest yet known for any species — was enough to ensure valid publication of the name.

Atrichum P.Beauv. 1804 — *a-* (lacking) + *trichos* (hair), from the almost complete lack of hairs on the calyptra, unlike other genera of Polytrichaceae: 'Coeffe...garnie au sommet de quelques poils courts et rares' (Palisot de Beauvois 1804: 329). The name is conserved against *Catharinea* Ehrh. ex D.Mohr 1803.

Aulacomnium Schwägr. 1827 — *aulacos* (furrow) + *mnion* (moss), alluding to the furrowing of the capsule when mature: 'Capsula sulcata' (Schwägrichen 1827: 51). The name is conserved against *Gymnocephalus* Schwägr. 1816, which Schwägrichen (who attributed the name to Hedwig) rejected on the basis that it was already in use (Schwägrichen 1827: 52). (Note that the pages in Schwägrichen (1827) were not numbered; the numbers given here refer to the folio number, as if the pages had been numbered.)

Barbella (Müll.Hal.) M.Fleisch. ex Broth. 1905 — Latin *barba* (beard) + diminutive suffix *-ellus*; 'The name makes reference to the long, slender, secondary stems forming graceful, pendent, beardlike masses.' (Crum & Anderson 1981). It was first suggested by Carl Müller (1896: 464) for a section of *Pilotrichella*.

Barbellopsis Broth. 1929 — *Barbella* + *opsis* (similar to), reflecting its affinity to *Barbella*: 'Ge[n]us novum *Barbellae* Fleisch. affine, sed foliorum cellulis alaribus numerosis quadratis diversum' (Brotherus 1929: 83).

Barbula Hedw. 1801 — Diminutive form of Latin *barba* (beard), alluding to the hairy appearance of the peristome: 'Peristomium simplex: dentibus capillaribus, spiraliter convolutis.' (Hedwig 1801: 115). The name is conserved against *Barbula* Lour. 1790 (Verbenaceae).

Bartramia Hedw. 1801 — After John Bartram (1699–1777), American colonist and botanist (Little 1941: 109). Bartram was appointed Royal Botanist in America, cofounded with Benjamin Franklin the American Philosophical Society, and was called by Linnaeus 'the greatest natural botanist in the world' (IHA 2007). Hedwig first published the name in 1789, although Linnaeus and Salisbury had both used it previously for vascular plants (Little 1941: 108). The name is conserved against *Bartramia* L. 1753 (Tiliaceae). Compare with *Bryobartramia*.

Beeveria Fife 1992 — A name honouring Jessica Beever, New Zealand bryologist in Auckland, noted in particular for the second edition of *The Mosses of New Zealand* (Beever *et al.* 1991) and her studies on *Fissidens* in Australasia, but also for many other contributions to our knowledge of mosses in the region. Allan Fife separated the single species, *B. distichophylloides* (Broth. & Dix.) Fife, from *Achrophyllum*.

Bescherellia Duby 1873 — After French botanist Émile Bescherelle (1826–1903), who worked mainly in New Caledonia and Mexico and wrote *Prodromus Bryologicae Mexicanae*: 'Genus cl. Aemilio Bescherelle, de bryologia mexicana et neo-caledonica optime merenti, dicatum.' (Duby 1873: 130).

Blindia Bruch & Schimp. 1846 — After J.J. Blind, pastor and botanical collector in Münster in the Vosges region of Germany from 1834 to 1848: 'Nomen in honorem reverend. Blind Vogesi superioris acutissimi investigatoris' (Schimper 1860: 119).

Brachydontium Fürnr. 1827 — *brachy* (short, stout) + *odon* (tooth), alluding to the imperfect peristome in which the teeth are often truncated. Fürnrohr also published the name as *Brachyodon* and *Brachyodus*, which are both illegitimate because they are orthographic variants.

Brachymenium Schwägr. 1824 — *brachy* (short, stout) + *hymen* (membrane), alluding to the short basal membrane (Bridel 1826–27: 601). Spence & Ramsay (2006) gave the second stem as *meninx* (membrane), but that would result in the name *Brachymeningium*.

Brachythecium Schimp. 1853 — *brachy* (short, stout) + *thekion* (little vessel, container), alluding to the rather short, fat capsule: 'Capsula...pro more

crassiuscula (unde nomen, βραχυ crassum)' (Schimper 1860: 531).

Braithwaitea Lindb. 1872 — After Robert Braithwaite (1824–1917), Yorkshire-born English physician and bryologist in London, best known in bryology for his three-volume illustrated *British Moss-flora* (1880–1905).

Breutelia (Bruch & Schimp.) Schimp. 1856 — After Johann Christian Breutel (1788– 1875), bishop and botanical collector in Herrnhut and missionary in the West Indies and South Africa: 'Genus hoc nitidissum, amicissimo Chr. Breutel, insul. St. Kitts et St. Thomas nec non Capitis b. spei perscrutatori, bryologo praestantissimo dicatum…' (Schimper 1860: 428).

Bruchia Schwägr. 1824 — After Philipp Bruch (1781–1847), 'pharmaceuta meritissimo, qui plantas Bipontii et Germaniae occidentalis sedulo colligit et acute observat' (Schwägrichen 1824: 91). Bruch was an apothecary and botanist in Zweibrücken, and with Wilhelm Schimper wrote the multi-volume *Bryologica Europaea*.

Bryobartramia Sainsb. 1948 — *bryon* (moss) + *Bartramia*, after Edward Bunting Bartram (1878–1964), American bryologist and descendant of John Bartram (see *Bartramia*). 'I take great pleasure in naming the family and genus after Mr E.B. Bartram to whom I am indebted for assistance in the study of the plant…' (Sainsbury 1948: 13).

Bryobeckettia Fife 1985 — *bryon* (moss) + *Beckett*, a name honouring Thomas Wrench Naylor Beckett (1839–1906), New Zealand orchardist and bryologist in Fendalton, 'a meticulous student of the mosses of New Zealand' (Fife 1985: 191). Beckett arrived in New Zealand in 1883 from Ceylon, where he had been a coffee planter (Godley 1997: 19) and botanical collector. He had already made significant plant collections in South Africa, Ceylon and the Himalaya, and his collections are contained in many herbaria around the world (Desmond 1994: 60).

Bryobrothera Thér. 1920 — After Viktor Ferdinand Brotherus (1849–1929), Finnish botanist and bryologist, pupil of S.O. Lindberg and friend of French bryologist Irénée Thériot (1859–1947) + *bryon* (moss). 'Je suis heureux de dédicer ce nouveau genre à mon savant ami V. F. Brotherus qui, le premier, en a eu l'intuition et dont les travaux ont puissamment aidé à faire connaître la flore bryologique de notre belle colonie du Pacifique.' (Thériot 1920: 27).

Bryodixonia Sainsbury 1945 — *bryon* (moss) + *Dixon*, a name honouring Hugh Neville Dixon (1861–1944), celebrated English bryologist in Northampton, noted in particular for *The Student's Handbook of British Mosses* (1896) reprinted several times and the standard text on the subject for more than a century. Dixon contributed dozens of papers on mosses as well as many other botanical subjects, and also wrote the book *Studies in the Bryology of New Zealand* (1929). See Bartram (1944) for a wonderful eulogy.

Bryoerythrophyllum P.C.Chen 1941 — *bryon* (moss) + *erythros* (red) + *phyllon* (leaf), 'referring to the brick-red colour of the most widespread species, *B. recurvirostrum*' (Crum & Anderson 1981). Zander (1986) noted that a reddish colouration is typical of the genus generally.

Bryostreimannia Ochyra 1991 — A name honouring Heinar Streimann (1938–2001), Estonian–Australian bryologist who collected the type (Ochyra 1990) + *bryon* (moss). Streimann was well known for his exsiccatae of Australian mosses, and for his contributions to our knowledge of Australian Hookeriaceae and the bryoflora of Norfolk Island. The name replaced *Streimannia* Ochyra, a later homonym of a lichen genus also named after Heinar Streimann.

Bryum Hedw. 1801 — *bryon*, an ancient name for an unidentified bryophyte, derived apparently from *bruein* (to swell, sprout or burgeon) (Scott 1988: 1).

Buxbaumia Hedw. 1801 — After Johann Christian Buxbaum (1693–1730), German botanist and professor in Petersburg, who in 1712 collected the type for the genus, *Buxbaumia aphylla*, on the banks of the Volga not far from Astrakhan (Greville & Arnott 1823–24: 86). Buxbaum had wanted to name the plant after his father, as Jean Marchant had done for *Marchantia*, but recalled the fox who was derided because he begged for grapes, not

for himself but for his sick mother (Buxbaum 1728: 9). Instead he called it *Muscus capillaceus aphyllos, capitulo crasso, bivalvi.* The name *Buxbaumia* was eventually given in honour of the younger Buxbaum by botanist and poet Albrecht von Haller in his *Enumeratio* (Haller 1742: 10), apparently thinking it was a fungus. Hedwig (1801: 166) and others attributed the name to Linnaeus, but he merely resurrected the name given by Haller after Girolamo Fabrici (Fabricius) had changed it to *Hippopodium.*

Caduciella Enroth 1991 —Latin *caducus* (falling easily) + diminutive suffix *-ellus*, alluding to the fragile leaves of the only species, *Caduciella mariei* — 'Stems to *ca* 2.5 cm long, erect, distal parts often naked due to caducous leaves' (Enroth 1991: 612).

Callicostella (Müll.Hal.) Mitt. 1859 — Latin *callosus* (thick) + *costa* (rib) + diminutive suffix *-ellus*, alluding to the thick (in transverse section) costa: 'nervis callosis' (Müller 1851: 216). Müller coined the name for a section of *Hookeria*, in which he placed *H. callicostata* Müll.Hal., *H. papillata* Mont. and numerous other species. Mitten raised the section to generic rank on the basis of the difference in leaf structure, but transferred only *H. papillata.* The name is conserved against *Schizomitrium* Schimp. 1851 (Magill 1993: 12).

Calliergidium (Renauld) Grout 1931 — Genus *Calliergon* + Greek diminutive suffix *-idion*, alluding to the similarity to that genus. Renauld (1902: 64) first coined the name for a subgenus of *Hypnum* to replace his illegitimate name *Pseudo-cal[l]iergon*, a later homonym of *Pseudo-calliergon* Limpr. Although he used the word 'propose' in that paper he clearly accepted and adopted the new name, transferring to it four species of *Hypnum.* Article 34.1 of the *Code* therefore does not apply in this case, and the authorship as given here is correct. Wynne (1945: 134) rejected the genus because she found that the types of species it comprised were identical to species in other genera described earlier. However, the genus stands in the New Zealand flora because Bartram (1946: 317) transferred *Hypnum austro-stramineum* Müll.Hal. to it.

Calliergonella Loeske 1911 — Genus *Calliergon* + Latin diminutive suffix *-ellus*, a name that William Sullivant coined for a section of *Hypnum* (Sullivant 1856: 72) presumably from *kallos* (fine, beautiful) + *ergon* (work), alluding to 'good or pretty workmanship, to an elegance of appearance' (Crum & Anderson (1981: 101). Loeske included in his new genus only one species, *Calliergonella* [*Calliergon*] *cuspidata* (Hedw.) Loeske (Loeske 1911: 248).

Calomnion Hook.f. & Wilson 1854 — *kalos* (beautiful) + *mnion* (moss), a simple descriptive name, although Hooker and Wilson did not state their etymology.

Calymperastrum I.G.Stone 1986 — *Calymperes* + Latin *astrum* (star), alluding to the earlier placement of the type (*C. latifolium*) in *Calymperes* and, although Ilma Stone did not say as much, to the star-like appearance of the plants.

Calymperes Sw. 1814 — *kalymma* (covering, veil) + *peres* (going beyond), 'so named because the calyptra forms a covering which surpasses (and encloses) the capsule' (Crum & Anderson 1981).

Calyptopogon (Mitt.) Broth. 1902 — *kalyptos* (enveloping) + *Streptopogon*, alluding to the large, smooth calyptra that completely covers the capsule, and the original placement as a section in *Streptopogon.* The capsule is exserted above the perichaetial leaves, so the name clearly does not refer to an immersed capsule as has been suggested elsewhere (compare *Calyptothecium*).

Calyptothecium Mitt. 1868 — *kalyptos* (enveloping) + *thekion* (little vessel, container), from the almost sessile capsule immersed in the perichaetial leaves: 'Theca aequalis, fere sessilis, perichaetio immersa…' (Mitten 1868: 190). The calyptra is small, so the name cannot refer to a large calyptra covering the capsule, as is sometimes suggested.

Calyptrochaeta Desv. 1825 — *kalyptra* (covering, veil) + *chaite* (hair, bristle), alluding to the hairy calyptra: 'Coiffe campaniforme velue.' (Desvaux 1825: 226). Desvaux coined the name to replace *Chaetophora* Brid., a later homonym of *Chaetophora* Nutt. (Asteraceae).

Camptochaete Reichardt 1870 — *kamptos* (bent, altered) + *chaite* (hair, bristle), I think alluding to the curved seta: 'durch die kurzen gekrümmen Fruchstiele' (Reichardt, in Fenzl 1870: 191).

Campylium (Sull.) Mitt. 1869 — *kampylos* (bent), alluding to the typically squarrose leaf acumen, a feature that subsequently led some workers to include unrelated species in this genus (Hedenäs 1997). The name was first applied by William Sullivant in 1856 to a section of *Hypnum*: 'leaves suddenly long-acuminate from a broadly ovate base, subsquarrose' (Sullivant 1856: 77).

Campylopodium (Müll.Hal.) Bescherelle 1873 — from genus *Campylopus*, alluding to the similarity of the seta to that in *Campylopus*: 'Plantae *Campylopodibus* simillimae pedunculis cygneo-recurvis' (Müller 1848: 429). Carl Müller first coined the name for a section of *Aongstroemia* Bruch & Schimp.

Campylopus Brid. 1819 — *kampylos* (bent) + *pous* (foot), alluding to the flexuose seta: 'ob setas in tota hac gente flexuosas, madore arcuatas' (Bridel 1826–27: 468).

Catagonium Müll.Hal. ex Broth. 1908 — *kata* (downwards) + *gone* (seed), alluding to the inclined capsule: 'Kapsel geneigt' (Brotherus 1905–09: 1087). Müller (1896: 468) did not give a diagnosis when he first attempted to erect the genus to encompass two Hawaiian species.

Catharomnion Hook.f. & Wilson 1855 — *katharos* (neat) + *mnion* (moss), alluding simply to the tidy appearance of the plants: 'Name from καθαρος, neat.' (Wilson 1854–55: 119).

Ceratodon Brid. 1826 — *keras* (horn) + *odon* (tooth), from the resemblance of the peristome teeth to the horns of a goat: 'dentes inflexione sua et trabeculis nodulosis caprae cornua referant' (Bridel 1826–27: 480).

Chaetomitrium Dozy & Molk. 1846 — *chaite* (hair, bristle) + *mitra* (head-dress), alluding to the densely hairy calyptra: 'Calyptra conico-mitraeformis, setosa, laciniata, pilis copiosis deflexis fimbriata.' (Dozy & Molkenboer 1846: 117).

Chenia R.H.Zander 1989 — After Pan-Chieh Chen (1907–1970), Chinese bryologist and teacher. He was the chief compiler of volume II of *Genera Muscorum Sinicorum* and worked on the taxonomy of East Asian Pottiaceae.

Chorisodontium (Mitt.) Broth. 1924 — *chorisos* (separated, distant) + *odontos* (toothed), alluding to separation of the peristome teeth at their bases: 'Peristomii dentes ad basin usque discreti' (Mitten 1869: 62). William Mitten originally coined the name for a section of *Dicranum*.

Chrysoblastella R.S.Williams 1903 — *chrysos* (golden) + *blaste* (bud) + Latin diminutive suffix *-ellus*, referring to the golden-yellow colour of the plants.

Cladomnion Hook.f. & Wilson 1854 — *klados* (branch) + *mnion* (moss), alluding to the bipinnate branching: 'We separate the following [species] from *Leskea* and *Neckera* on account of the habit of growth, and the strong resemblance of the fruit to that of *Leucodon*.' (Hooker & Wilson 1854: 99).

Claopodium (Lesq. & Jam.) Renauld & Cardot 1893 — probably from *klao* (I weep) + *pous* (foot), alluding to the weeping (pendent) capsule: 'Capsule turgid, abruptly bent down at the base of the collum...' (Lesquereux & James 1884: 317). The name was coined by Lesquereux and James for a subgenus of *Hypnum* comprising five species. It has been suggested that the first stem is *klao* (to break off), but that makes no sense in relation to the original description and the characters outlined there.

Clastobryum Dozy & Molk. 1846 — *klastos* (broken) + *bryon* (moss) alluding to the great fragility of the generitype, *Clastobryum indicum*: 'Caulis...admodum fragilis subaphyllus seu foliorum vetustomum vestigis...' (Dozy & Molkenboer 1846: 45).

Climacium F.Weber & D.Mohr 1804 — *klimax* (staircase, ladder), 'alluding to the appearance of the processes of the inner peristome, the two halves of which are regularly united by projections between the perforations, giving somewhat the appearance of a ladder' (Dixon 1954). 'Peristomium...cruribus per trabes apiceque connexis' (Weber & Mohr 1807: 252).

Conostomum Sw. 1804 — *konos* (cone) + *stoma* (mouth), alluding to the fusing of the tips of the peristome teeth to form a cone (Bridel 1826–27: 150; Schimper 1860: 422; Crum & Anderson 1981: 641).

Coscinodon Spreng. 1804 — *koskinon* (sieve) + *odon* (tooth), alluding to the sieve-like peristome teeth: 'peristomii dentes...majusculi, late lanceolati,

remote articulati, pro more valde cribrosi (unde generis nomen κοσκινον cribrum et οδον dens)' (Schimper 1860: 242).

Cratoneuropsis (Broth.) M.Fleisch. ex Broth. 1923 — *Cratoneuron* + *opsis* (similar to), alluding to the similarity to that genus. The name *Cratoneuron* is from *kratos* (strong) + *neuron* (nerve), alluding to the strong costa: 'costa stout, subcontinuous' (Sullivant 1856: 73).

Crosbya Vitt 1977 — A name honouring Marshall Crosby, U.S. bryologist at the Missouri Botanical Garden, noted expert in the systematics of mosses.

Crossidium Jur. 1882 — *krossoi* (fringe) + diminutive suffix *–idion*, alluding to 'the dense fringe provided by filaments covering the costa in the upper part of the leaf' (Crum & Anderson (1981: 356). The name is conserved against *Chloronotus* Venturi 1868.

Cryphaea D.Mohr & F.Weber 1814 — *krypha* (secret, hidden), a variant of *kryptos*, alluding to the immersed capsules, more or less hidden by the perichaetial leaves: 'ob capsulas in perichaetio latitantes' (Schimper 1860: 462).

Cryptogonium (Müll.Hal.) Hampe 1880 — *kryptos* (hidden) + *gone* (seed), alluding to the position of the capsules, immersed in the perichaetial leaves (Müller 1874: 69).

Ctenidium (Schimp.) Mitt. 1869 — *ktenos* (comb) + diminutive suffix *–idion*, alluding to the neat, comb-like appearance of the branching: 'ramosae confertim et regulariter pinnato-ramulosae ita ut in utroque caulis latere eleganter pectinatae videantur (unde nomen)' (Schimper 1860: 631). Schimper coined the name for a subgenus of *Hypnum* comprising a single species, *H. molluscum* Hedw.

Cyathophorum P.Beauv. 1804 — *kyathos* (wine ladle, cup) + *phoreos* (to bear), referring to the shape of the capsule: 'gaine longue, cylindrique, très-ouverte, cyathiforme' (Palisot de Beauvois 1804: 324).

Cyclodictyon Mitt. 1864 — *kyklos* (circle) + *diktyon* (net), alluding to the supposedly rounded leaf cells: 'They differ from the *Hookeria*...and *Lopidium*... in the large rounded cells of their leaves' (Mitten 1864: 163–164).

Cyptodon (Broth.) Paris & Schimp. 1914 — *kypto* (procumbent) + *odon* (tooth), alluding to the more or less horizontal peristome teeth: 'propter dentes (coriaceos) vivos madefactosve peristomi orificium capsulae fere horizontaliter obtegentes' (Paris & Schimper 1914: 310). Brotherus first coined the name for a subgenus of *Cryphaea*, noting 'Zähne des aüßeren [Peristom] feucht fast horizontal einwärtsgebogen' (Brotherus 1905–09: 743).

Cyrtopus (Brid.) Hook.f. 1867 — *kyrtos* (curve, bend) + *pous* (foot), referring to the curved seta: 'pedunculo subarcuato' (Bridel 1926–27: 235). Bridel originally coined the name for a section of *Neckera*.

Daltonia Hook. & Taylor 1818 — After James Dalton (1764–1843), British clergyman, botanist and bryologist in Yorkshire. 'With much pleasure we here offer our tribute of affectionate regard to our valued friend, the Rev. James Dalton, by whose muscological communications we have frequently profited during the collection of the materials for the present volume.' (W.J. Hooker & Taylor 1818: 80). The name is not, as is sometimes claimed, related to his grandson, James Dalton (d. 1862). The name is conserved under the *Code*.

Dawsonia R.Br. 1811 — After Dawson Turner (1775–1858), banker, botanist, antiquarian and artist, a close friend of Robert Brown: 'I have named this remarkable genus in honour of my esteemed friend Dawson Turner, Esq., a gentleman eminently distinguished in every part of Cryptogamic botany, and from whom, after he has finished the incomparable work on *Fuci*, in which he is now engaged, we may expect a general history of Mosses.' (Brown 1811: 318). Turner died on 20 June 1858, ten days after Brown.

Dendrocryphaea Paris & Schimp. ex Broth. 1905 — *dendron* (tree) + *Cryphaea*, alluding to the habitat of the species.

Dendroligotrichum (Müll.Hal.) Broth. 1905 — *dendros* (tree) + *oligos* (few, little) + *trichos* (hair, bristle), alluding to the great size and dendroid habit, and the sparse hairs on the calyptra: 'Plantae saepe giganteae' (Müller 1849: 199).

Dichelodontium Hook.f. & Wilson ex Broth. 1907 — *dichelos* (two-headed arrow) + *odontos* (toothed),

alluding to the half-split peristome teeth. The name was coined by Joseph Hooker and William Wilson in relation to *Leucodon nitidus* Hook.f. & Wilson: 'if ever generically separated we propose the name *Dichelodontium*' (FI NZ 2: 99). Brotherus followed their lead in separating the species from *Leucodon*.

Dicnemon Schwägr. 1824 — *diken* (in the manner of, like) + *kneme* (leg bone). Although Schwägrichen (1824: 126) noted merely 'a κνημη, crus' (i.e. 'from *kneme*, leg bone'), it is clear that the name refers to the peculiar shape of the capsule, whereby a basal projection gives it the appearance of the head of a femur.

Dicranella (Müll.Hal.) Schimp. 1856 —Genus *Dicranum* + Latin diminutive suffix *–ellus*. Carl Müller coined the name for a section of *Aongstroemia* Bruch & Schimp., comprising three species previously included in *Dicranum* Hedw. The name is conserved under the *Code*.

Dicranoloma (Renauld) Renauld 1901 — Genus *Dicranum* + *loma* (border), alluding to the border of narrow, elongate cells on the leaf margin: 'limbum hyalinum 23–35 μ latum, 3–5-seriatum, ultra folii medium productum efformatibus' (Renauld & Cardot 1915: 70).

Dicranoweisia Lindb. ex Mild. 1869 — Compounded form of *Dicranum* and *Weisia* (a variant of *Weissia*); 'The name reflects a relationship to *Dicranum* and some resemblance to *Weissia*' (Crum & Anderson 1981). See *Weissia* for a discussion on the variant spelling.

Dicranum Hedw. 1801 — *dikranos* (two-pronged fork), relating to the divided peristome teeth: 'Peristomium simplex; dentibus sedecim brevioribus, inflexis, bifidis.' (Hedwig 1801: 126).

Didymodon Hedw. 1801 — *didymos* (twofold) + *odon* (tooth), referring to the division of the peristome teeth: 'Denticulorum linearium sedecim paria basi non connexa.' (Hedwig 1801: 104).

Diphyscium D.Mohr 1803 — *di* (two) + *physcion* (vesicle), 'the wide separation of the thecal and sporangial membranes giving the appearance of one vesicle inside another' (Sullivant 1856: 40).

Distichium Bruch & Schimp. 1846 — *distichos* (in two rows), alluding to the arrangement of the leaves: 'Nomen a διστιχος, bifarius, ob foliorum dispositionem bifarium.' (Schimper 1860: 135). The name is conserved against *Cynodontium* Hedw. 1801.

Distichophyllum Dozy & Molk. 1846 — *distichos* (in two rows) + *phyllon* (leaf), alluding to the apparently distichous (but in fact complanately flattened) arrangement of the leaves: 'Folia…laterali disticha subhorizontalia' (Dozy & Molkenboer 1846: 100).

Ditrichum Hampe 1867 — *di* (two) + *trichos* (hair), referring to the filiform, divided peristome teeth: 'Peristoma simplex: Dentes 33. filiformes per paria approximati, basi non cohaerente' (Timm 1788: 216). The genus was erected by Timm before the starting date for moss nomenclature, but the name is preserved because Hampe republished it to replace his own synonymous *Leptotrichum* (Hampe 1867: 181). The name is conserved against *Ditrichum* Cass. 1817, *Diaphanophyllum* Linb. 1863, *Aschistodon* Mont. 1845, *Lophiodon* Hook.f. & Wilson 1844 and *Trichodon* Schimp. 1856.

Drepanocladus (Müll.Hal.) G.Roth 1899 — *drepanon* (sickle) + *klados* (branch, shoot), alluding to the appearance of the falcate-secund leaves: 'folia distincte falcata uncinata' (Müller 1851: 321). Roth (1899: 6) raised Müller's section of *Hypnum* to generic rank. The name is conserved against *Drepanocladus* Müll.Hal. 1898 and *Drepanohypnum* Hampe 1872.

Eccremidium Wilson 1846 —*ekkremos* (pendulous) + diminutive suffix *–idion*, referring to the pendulous capsule: 'the new generic name, *Eccremidium*, is proposed for a genus characterised by the short, thick, arcuate seta, and pendulous capsule' (Wilson 1846a: 450–451).

Echinodium Jur. 1866 — *echinos* (hedgehog) + diminutive suffix *–idion*, alluding to the spiky appearance of the plants, which have long, stiff, widely spreading leaves.

Ectropothecium Mitt. 1868 — *ektrope* (turned aside) + *thekion* (little vessel, container), alluding to the capsule: 'The capsule is in all the species…perfectly pendulous when old, supported on a long seta, curved only at its apex' (Mitten 1868: 180).

Encalypta Hedw. 1801 — *en* (within) + *kalyptos* (enveloping), clearly alluding to the remarkably large calyptra which covers and extends below the capsule.

Entodon Müll.Hal. 1845 — *entos* (inside) + *odon* (tooth), alluding to the insertion of the outer peristome teeth inside the capsule mouth: 'Peristomium duplex. Externum: Dentes…intra orificium orientes' (Müller 1845: 704).

Entosthodon Schwägr. 1823 — *entosthen* (inside) + *odon* (tooth); 'Nomen ab εντοσθεν, intus: et οδους, dens' (Schwägrichen 1823: 44), that is, alluding to the position of the inner peristome, well below (and thus inside) the mouth of the capsule.

Ephemeropsis K.I.Goebel 1892 — *Ephemerum* + *opsis* (similar to), alluding to the resmblance to that genus.

Ephemerum Hampe 1837 — *ephemeros* (short-lived), alluding to the supposed ephemeral life cycle of the plants (Hampe 1837: 98). The name is conserved against *Ephemeron* Mill. 1754 (Commelinaceae).

Epipterygium Lindb. 1862 — *epi* (almost, near) + *pterygion* (little wing), presumably referring to the appearance of the upper leaves, which are almost distichous and resemble wings, somewhat like *Mittenia*. The genus has been treated as a section of *Bryum*, *Pohlia* and *Webera* and a subgenus of *Bryum* by various authors.

Eriodon Mont. 1845 —*eriodon* (with large teeth), alluding to the very long peristome teeth: 'Nomen ex εριοδον, magnos habens dentes, ductum' (Montagne 1845: 98).

Erpodium (Brid.) Brid. 1827 — *erpo* (creeping), a name 'appropriately chosen, in the context of the original publication, as a subgeneric division of *Anoectangium*' (Crum & Anderson 1981). Bridel (1827: 167) published the name as a subgenus of *Anoectangium* characterized by creeping stems ('caule repente'), but raised it to generic rank on page 788 of the same work. In the absence of capsules members of this genus might be passed over as a member of the liverwort family Lejeuneaceae. Indeed, *E. biseriatum* was originally named *Lejeunia* [*Lejeunea*] *biseriata* by Austin, 'an astute bryologist' (Crum & Anderson 1981).

Eucamptodon Mont. 1845 — *eu*– (well, finely) + *kamptos* (bent, altered) + *odon* (tooth), alluding to the strongly incurved peristome teeth of the type, *E. perichaetialis* Mont.: 'dentibus 16 carnosis rubris madore incurvo-conniventibus' (Montagne 1845: 119).

Eucladium Bruch & Schimp. 1846 — *eu* (well) + *klados* (branched), alluding to the repeatedly dichotomous branching: 'innovationibus repetitis multoties dichotome ramosae (unde nomen ευ et κλαδος)' (Schimper 1860: 134).

Euptychium Schimp. 1866 — *eu*– (well, finely) + *ptychos* (folded, cleft), alluding to the pluriplicate leaves.

Eurhynchium Bruch & Schimp. 1854 — *eu* (well, finely) + *rhynchion* (beak), alluding to the long, slender beak of the operculum: 'Operculum in rostrum plus minus elongatum productum (unde nomen)' (Schimper 1860: 548).

Exostratum L.T.Ellis 1985 — *exos* (outside) + Latin *stratum* (layer), from the continuous layer of chlorocysts over the supporting hyalocysts in the leaves (Ellis 1985: 9). Len Ellis coined the name for Cardot's section 'B' of *Exodictyon*.

Fabronia Raddi 1808 — After Florentine administrator Giovanni Valentino Mattia Fabroni, at one time director of the mint in Florence: 'In honores Fabroni monetae excudendae Praefecti Florentini nomen conditum.' (Müller 1851: 31). According to Crum & Anderson (1981) the name was chosen partly as a derivation from the Latin *faber*, meaning ingenious. Raddi later named the liverwort genus *Pellia* after Fabroni's son Leopoldo Pelli Fabroni, a lawyer (Raddi 1818: 50).

Fallaciella H.A.Crum 1991 — Latin *fallacia* (deceit or trick) + diminutive suffix *–ellus*. 'The generic name was chosen because of the fallaceous or deceitful nature of this interesting moss, with its strong gametophytic resemblance to an unrelated genus, *Pterigynandrum*.' (Crum 1991: 320).

Fifea Crum 1991 — 'I give this species of New Zealand generic status, in the Lembophyllaceae, as *Fifea*, named for Allan J. Fife in recognition of his contribution to the bryology of New Zealand.' (Crum 1991: 319).

Fissidens Hedw. 1801 — Latin *fissus* (a split) + *dens* (tooth), alluding to the split peristome teeth: 'dentibus sedecim, latiuscuis, bifidis' (Hedwig 1801: 152).

Floribundaria M.Fleisch. 1905 — Latin *floribundus* (a profuse flowering) + *aris* (resembling), alluding to the abundance of sporophytes. Carl Müller had proposed the name in 1876 in anticipation of its later acceptance, so that Article 34.1 of the *Code* applies and Fleischer alone is the authority: 'In dieser Beziehung zeigen die Papillarien eine ähnliche gruppenweise Verarbeitung, wie unter Hypnum etwa die Sigmatella-Gruppe, und es ist deshalb zweckmässig, unsere obigen drei Arten als *Floribundaria* beisammen zu halten.' (Müller 1876: 267).

Forsstroemia Lindb. 1863 — After Johann Eric Forsström (1775–1824), Swedish clergyman, physician and naturalist on St Barthélemy in the Lesser Antilles, who collected the type specimen of *Forsstroemia trichomitria* (Hedw.) Lindb.: 'Lindberg…created the genus *Forsstroemia*…in honor of a minister who was a collector of mosses in the West Indies' (Patterson 1953: 254).

Funaria Hedw. 1801 — Presumably from Latin *funis* (cord) + *aris* (resembling), alluding to the twisted, cord-like seta of *F. hygrometrica*: 'Nomen Schreberianum a fune desumptum, quod pedunculus in F. hygrometrica humiditate funis instar contorquetur.' (Bridel 1827: 50). However, Johann Schreber, who coined the name in the 8th edition of *Genera Plantarum* (Schreber 1791: 760), gave no explanation of the etymology, nor did Hedwig (1801). It is noteworthy that Palisot de Beauvois (1804: 320) proposed to replace *Funaria* with *Strephidium* because, he said, the former was constructed from a personal name (i.e. Funari), a practice he disliked. Hedwig had earlier coined the name *Koelreutera* for the same plant (*Funaria hygrometrica* Hedw.) but that was a later homonym for *Koelreutera* J.A.Murray, a genus of Aizoaceae.

Garckea Müll.Hal. 1845 — After German botanist (Christian Friedrich) August Garcke (1819–1904), noted in particular for his monumental *Illustrierte Flora, Deutschland und angrenzende Gebiete* (1848), of which 23 editions were printed, the last in 1972. Garcke would have been only in his mid-20s when Carl Müller named this pan-tropical genus.

Garovaglia Endl. 1836 — After Santo Garovaglio (1805–1885), professor of botany in Lombardy, who was instrumental in establishing the Laboratorio di Botanica Crittogamica in Pavia (Belli *et al.* 2004). Endlicher coined the name (as *Carovaglia*, an orthographic error) to replace *Esenbeckia* Brid., a later homonym of *Esenbeckia* Mart. (Rutaceae).

Gemmabryum J.R.Spence & H.P.Ramsay 2005 — *gemma* (a bud or propagule) + genus *Bryum*, from which it was separated: 'the name refers to the importance of the three different types of asexual gemmae in the genus' (Spence & Ramsay 2006).

Gigaspermum Lindb. 1865 — *gigas* (giant) + *sperma* (seed), alluding either to the size of the capsule, which is huge in comparison to the gametophyte, or to the size of the spores, which reach up to 130 µm in diameter.

Glossadelphus M.Fleisch. 1923 — *glossa* (tongue) + *adelphos* (brother), alluding to the tongue-shaped leaves — 'mehr oder minder länglich zungenförmigen, selten zugespitzten Blätter' (Fleischer 1923: 1352) — and presumably the similarity to *Taxithelium* from which *Glossadelphus* was separated.

Glyphothecium Hampe 1860 — *glyphos* (engraved) + *thekion* (little vessel, container), alluding to the strongly ridged capsules.

Goniobryum Lindb. 1865 — *gonio* (angular) + *bryon* (moss). Lindberg's intention is unclear, but the name is possibly merely a convenient derivation from *Rhizogonium* (from which it was separated) with the common *bryum* ending for moss genera.

Goniomitrium Hook.f. & Wilson 1846 — *gonio* (angular) + *mitra* (head-dress), a reference to the pleated calyptra: 'Calyptra campanulata, magna, speciosa, 8-costata, junior plicata.' (Wilson 1846b: 142).

Grimmia Hedw. 1801 — After Johann Friedrich Karl Grimm (1737–1821), physician and botanist in Gotha (Dixon 1954), mentioned by Kayser-Petersen in relation to the influenza epidemic of 1767 (Kayser-Petersen 1923). The name was first coined by Friedrich Ehrhardt (Bridel 1826–27: 161).

Groutiella Steere 1950 — After American teacher and bryologist Abel Joel Grout (1867–1947), author of several classic treatises on mosses, notably *Mosses with Hand-lens and Microscope* and the three-volume *Moss Flora of North America*. The name *Groutia* was already in use for a genus of flowering plants (Opiliaceae).

Gymnostomiella M.Fleisch. 1904 — Genus *Gymnostomum* + Latin diminutive suffix *–ellus*, reflecting its separation from *Gymnostomum* and the minute size of the plants: 'Pflanzen winzig klein' (Fleischer 1904: 309).

Gymnostomum Nees & Hornsch. 1823 — *gymnos* (naked) + *stoma* (mouth), alluding to the lack of a peristome: 'ob thecae orificium nudum' (Bridel 1826–27: 57). The name was coined by Hedwig (1787: 13) and is conserved against *Gymnostomum* Hedw. 1801.

Hampeella Müll.Hal. 1881 — After Ernst Georg Ludwig Hampe (1795–1880), German pharmacist and bryologist in Blankenburg, who contributed considerably to the knowledge of mosses as well as other plants. The name *Hampea* was already in use for a genus of flowering plants.

Haplohymenium Dozy & Molk. 1846 — *haploos* (single, simple) + *hymenium* (an old name for the peristome), alluding to the single peristome: 'Peristomium simplex e dentibus sedecim aequidistantibus...' (Dozy & Molkenboer 1846: 127). The name is conserved against *Haplohymenium* Schwägr. 1829.

Hedwigia P.Beauv. 1805 — After Johann Hedwig (1730–1799), physician and botanist in Leipzig, called by Dixon (1854) the 'Father of Bryology'. His most significant works were *Fundamentum Historiae Naturalis Muscorum Frondosorum* (1782), *Descriptio et Adumbratio Microscopico-Analytica Muscorum Frondosorum* (1787–1797) and *Species Muscorum Frondosorum* (1801). The latter is the starting point for all moss nomenclature except *Sphagnum*, and was prepared for publication after Hedwig's death by Schwägrichen. The name is conserved against *Hedwigia* Sw. 1788 (Burseaceae).

Hedwigidium Bruch & Schimp. 1846 — Genus *Hedwigia* + Greek diminutive suffix *–idion*, alluding to the similarity to that genus: 'ob similitudinem cum gen. *Hedwigia*' (Schimper 1860: 239).

Helicodontium (Mitt.) A.Jaeger 1878 — *helix* (coil, curl) + *odontos* (toothed), 'from the peristome, curling inwards when dry' (Dixon 1954: 406). Mitten coined the name for a section of *Hypnum*, but did not mention this character in the diagnosis of the section or the descriptions of species.

Hennediella Paris 1896 — After Roger Hennedy (1809–1877), Scottish phycologist and Professor of Botany at Anderson's University in Glasgow, teacher and friend of Robert Brown (Blockeel 1990). The name *Hennedia* had been applied for the genus by Brown in 1892 but this was an orthographic variant of the earlier algal genus *Hennedya* Harvey 1855, so Paris replaced it in an appropriate manner.

Herpetineuron (Müll.Hal.) Cardot 1905 — *herpeton* (creeping animal, reptile) + *neuron* (nerve), alluding to the characteristic snaking of the costa in the upper part of the leaf: 'nervo validiusculo luteo apice parum serpentino-flexuoso in acumine evanido exarata' (Müller 1890a: 496). Müller coined the name for a section of *Anomodon* that was raised to generic rank by Cardot.

Himantocladium (Mitt.) M.Fleisch. 1908 — *himantos* (leather thonging) + *klados* (branch), presumably alluding to the appearance of the complanate, overlapping leaves, resembling thonging on a whip handle or the like. Mitten (1868: 168) coined the name for a section of *Neckera* in which he included three species.

Holomitrium Brid. 1826 — *holos* (complete) + *mitra* (head-dress), alluding to the entire calyptra (Bridel 1826–27: 226). Bridel published the name as *Olomitrium*, ignoring the aspirated 'h'. The name and corrected orthography are conserved under the *Code*.

Homalia Brid. 1827 — *homalos* (flat), from the complanate habit of the plants, particularly of *Homalia complanata* (Bridel 1827: 812). Bridel's original name *Omalia*, lacking the aspirated *h*, was corrected to *Homalia* by Wilhelm Schimper. The name and corrected orthography are conserved under the *Code*.

Homaliodendron M.Fleisch. 1906 — *homalos* (flat) + *dendron* (tree), alluding to the flattened dendroid branches that arise from a creeping primary stem:

'Pflanzen breit, flach, wedelartig, zwei- bis dreifach gefiedert…' (Fleischer 1905–06: 74).

Hookeriopsis (Besch.) A.Jaeger 1907 — *Hookeria* + *opsis* (similar to). Bescherelle coined the name for a subgenus of *Hookeria*, a genus named after William Jackson Hooker (1785–1865), renowned English botanist and collaborator with Thomas Taylor on *Muscologica Brittanica*.

Hylocomium Bruch & Schimp. 1852 — *hylokomos* (forest-dwelling), alluding to the habitat of the plants: 'Habitatio terrestris, sylvatica, unde nomen, υλοκομοσ sylvicola' (Bruch *et al.* 1851–55: 169). Schimper (1860: 656) treated *Hylocomium* as a subgenus of *Hypnum* but maintained the binomial combinations in *Hylocomium*. The name is conserved under the *Code*.

Hymenodon Hook.f. & Wilson 1844 — *hymen* (membrane) + *odon* (tooth), alluding to the membranous peristome: 'dentes sedecim, membranacei, fugaces, aequidistantes, linearisubulati imperforati in cupulam conniventes apicibusque cohaerentes, membrana basilari angusta persistente connexi…Nomen ab υμην et οδων' (J.D. Hooker & Wilson 1844: 548).

Hymenostomum R.Br. 1819 — *hymen* (membrane) + *stoma* (mouth), from the membrane covering the mouth of the capsule: 'the mouth of the capsule is…completely covered by a horizontal membrane…derived from the outer membrane of the capsule' (Brown 1819: 572). Brown established the genus as a segregate from *Leptostomum*, which William Hooker had included in *Gymnostomum*.

Hyophila Brid. 1827 — *hyo* (water, rain) + *philos* (loving). Bridel (1826–27: 761), alluding to the habitat, close to or in water. Bridel coined the name to replace *Rottleria* Brid. 1826, a later homonym of *Rottleria* Willd. 1797. A common name for the genus is 'water moss' or 'rain moss'. The name is not derived from *hydros* (water) or *hygros* (wet), as is sometimes claimed. The name is conserved under the *Code*.

Hypnobartlettia Ochyra 1985 — *hypnon* (moss) + *Bartlett*, 'in honour of my friend John K. Bartlett, who collected the moss for the first time and who has contributed much to our understanding of the moss flora of New Zealand' (Ochyra 1985: 3). John Bartlett contributed numerous papers on mosses, especially in *New Zealand Journal of Botany*, often collaborating with bryologists from overseas.

Hypnodendron (Müll.Hal.) Lindb. 1861 — *hypnon* (moss) + *dendron* (tree), alluding to the dendroid habit of the plants, which resemble miniature palms or tree-ferns.

Hypnum Hedw. 1801 — *hypnon*, an ancient name for an unidentified bryophyte, probably a moss. Note that the stem is not the often-quoted *hypnos*, which means 'sleep'. The name is conserved under the *Code*.

Hypopterygium Brid. 1827 — *hypo* (under) + *pterygion* (little wing), alluding to the position of the female inflorescences, nestling in the axils of the 'accessory leaves' or underleaves: 'ob situm floris foeminei sub tutela folii accessorii tegminalis nidulantis' (Bridel 1827: 709). It is often stated incorrectly that the name refers to the underleaves themselves.

Ischyrodon Müll.Hal. 1875 — *ischyros* (strong) + *odon* (tooth), alluding to the robust teeth of the single peristome: 'peristomium simplex externum: dentes 16 robusti lati elongati…' (Müller 1875: 443).

Isocladiella Dixon 1931 — *iso* (equal) + *clados* (branch) + Latin diminutive suffix *-ellus*, alluding to the more or less pinnate branching.

Isopterygium Mitt. 1869 — *iso* (equal) + *pterygion* (little wing). Like most of Mitten's names, the meaning is obscure. Crum and Anderson (1981: 1175) suggested that it could refer to 'the fact that the lateral leaves are, in most species, somewhat spreading and flattened together in two indistinct rows'.

Kiaeria I.Hagen 1915 — After Frantz Casper Kiær (1835–1893), Norwegian physician and bryologist in Christiana (Oslo) (Crum & Anderson 1981, Koperski 1991), contemporary of Norwegian bryologist Ingebrigt Hagen (1852–1917).

Lembophyllum Lindb. 1872 — *lembos* (skiff) + *phyllon* (leaf), alluding to the boat-shaped leaves.

Leptobryum (Schimp.) Wilson 1855 — *leptos* (slender) + *bryon* (moss), a reference to the narrow, wispy appearance of the plants: 'Plantae…graciles' (Schimper 1860: 328) and 'Leaves very narrow, almost setaceous' (Wilson 1855: 242).

Leptodictyum (Schimp.) Warnst. 1906 — *leptos* (slender, weak) + *dictyon* (net), apparently alluding to the areolation of the leaves: 'Foliorum rete angustius, tenue, areolis rhomboideo-hexagonis, prosenchymaticis, solis basilaribus rectangulo-hexagonis parenchymaticis, omnibus parce chlorophyllosis' (Schimper 1860: 595). Schimper fist coined the name for a subgenus of *Amblystegium*, which was raised to generic rank by Warnstorf.

Leptodon D.Mohr 1803 — *leptos* (slender, delicate) + *odon* (tooth), alluding to the narrow peristome teeth (Wilson 1855: 317). The name is conserved under the *Code*.

Leptodontium (Müll.Hal.) Hampe ex Lindb. 1864 — *leptos* (slender, delicate) + *odontos* (toothed), alluding to the peristome of 32 narrow teeth: (Müller 1849: 577). Hampe (1847: 70) first coined the name, but only with the intention in the future of separating two species from *Didymodon* and *Trichostomum* ('Bei späterer Gelegenheit ein Mehreres.') so Article 34.1 of the *Code* applies to the authority.

Leptostomum R.Br. 1811 — *leptos* (slender, delicate) + *stoma* (mouth), alluding to the rudimentary peristome, consisting of a papillose annular membrane: 'The character of *Leptostomum*, derived from the undivided annular process of the inner membrane of the capsule…' (Brown 1811: 322). Brown noted that Hedwig had drawn the peristome of *Bryum* [*Leptostomum*] *macrocarpum* Hedw. with teeth, although he could not find any himself. As he did not wish to be 'in opposition to such authority', Brown did not include *B. macrocarpum* in his new genus. The name is conserved under the *Code*.

Leptotheca Schwägr. 1824 — *leptos* (slender, delicate) + *thekion* (little vessel, container), alluding to the narrow capsule: 'Capsulae cylindricae, angustae' (Schwägrichen 1824: 135).

Leptotrichella (Müll.Hal.) Lindb. 1865 — Genus *Leptotrichum* + Latin diminutive suffix *-ellus*. The name *Leptotrichum* is derived from *leptos* (slender, delicate) + *trichos* (hair), referring to the fine peristome teeth: 'perist. dentibus linea media plerumque exaratis igitur saepe medio secedentibus' (Müller 1848: 421). Müller established *Leptotrichella* for a section of *Seligeria* in which he included several species he had previously placed in *Leptotrichum* Hampe ex Müll.Hal. His comment 'An genus proprium?' was taken up by Sextus Lindberg in raising the section to generic rank.

Lepyrodon Hampe 1865 — *lepyros* (stripped off) + *odon* (tooth), alluding either to the lack of an outer peristome in the species then known, or to the dehiscent inner peristome teeth: 'Peristomium simplex, internum; membrana in cruribus 16 elongatis carinatis, medio pertusis, demum dehiscentibus…' (Hampe 1865: 367).

Leucobryum Hampe 1839 — *leukos* (white) + *bryon* (moss), clearly alluding to the typically almost white colour (usually very pale green to bluish-green), although Hampe did not say so in the protologue (Hampe 1839: 42).

Leucoloma Brid. 1827 — *leukos* (white) + *loma* (border), alluding to the pale border on the leaves: 'foliorum colorem marginalem album in sola nobis cognita specie designans' (Bridel 1827: 218). The name is conserved against *Macrodon* Arn. 1826 and *Sclerodontium* Schwaägr. 1824.

Leucomium Mitt. 1868 — *leukoma* (white tablet), alluding to the 'soft, pale, almost white foliage of the species belonging to this genus' (Mitten 1868: 181).

Leucophanes Brid. 1826 — *leukos* (white) + *phainos* (appearance), referring to the typically pale colour of the plants (Bridel 1826–27: 763).

Lindbergia Kindb. 1897 — A name honouring Sextus Otto Lindberg (1835–1889), Swedish-born physician, naturalist and bryologist. He succeeded William Nylander to the chair in botany at the Botanical Museum in Helsingfors (Helsinki), where he lived for the rest of his life, and later was appointed director of the botanical gardens there.

Lopidium Hook.f. & Wilson 1854 — *lopis*, an unusual variant of *lepis* (scale) + diminutive suffix *-idion*, alluding to the overlapping leaves, like the scales of a fish, etc. 'Name from λοπις, a scale' (Wilson 1854–55: 119).

Macgregorella E.B.Bartram 1939 — After Richard Crittenden McGregor (1871–1936), ornithologist and naturalist in the Philippines, who collected the

type, *Macgregorella philipp[in]ensis* (= *M. indica*) from Luzon (Bartram 1939: 285). He was managing editor of the Philippines Journal of Science (in which Bartram published the new genus after McGregor's death) and at one time Acting Director of the Bureau of Science there. 'Many species of insects and other animals, as well as of plants, have been described or recorded from different parts of the Philippines…on the basis of material brought back by McGregor from his numerous field trips.' (Uichanco 1937).

Macrocoma (Müll.Hal.) Grout 1944 —*makros* (large) + *coma* (hair of the head), alluding to the long, dense hairs on the calyptra of *M. sullivantii* (Müll.Hal.) Grout.

Macrohymenium Müll.Hal. 1847 —*makros* (large) + *hymenium* (an old name for the peristome), alluding to the large peristome teeth.

Macromitrium Brid. 1819 — *makros* (large) + *mitra* (cap), alluding to the conspicuously long calyptra: 'ob calyptrae insignem longitudinem' (Bridel 1826–27: 306).

Meesia Hedw. 1801 — After David Meese (1723–1770), Dutch gardener, author of a flora of Friesland in 1760 (Dixon 1954, Koperski 1991). The name is conserved against *Meesia* Gaertn. 1788 (Ochnaceae).

Meiotheciella B.C.Tan, W.B.Schofield & H.P.Ramsay 1998 — Genus *Meiothecium* + diminutive suffix *–ellus*, alluding to the original placement of the species transferred to the new genus.

Meiothecium Mitt. 1868 — *meion* (smaller) + *thekion* (little vessel, container), alluding to the small capsule: 'theca parva, breviter pedunculata' (Mitten 1968: 185).

Mesochaete Lindb. 1870 — *mesos* (in the middle, between) + Latin *perichaetium* (fruit-stalk), alluding to the development of sporophytes in the axils of the leaves, rather than at the top of the stems (Lindberg 1870: 463). Sextus Lindberg, in the same work, also named the genus *Pleurochaete* for the same reason.

Mesonodon Hampe 1865 — *mesos* (in the middle, between) + *odon* (tooth), alluding to the presence of a preperistome: 'Peristomium simplex, intermedium (in pariete intermedia thecae oriundum)' (Hampe 1865: 347).

Mesotus Mitt. in Hook.f. 1867 — *mesotes* (middle or central position). Allen (1987a: 445) suggested that the name referred to the presumed intermediate systematic position of the genus: 'Mitten says it has the structure of leaf of *Symblepharis*, creeping stem of *Macromitrium* and teeth of *Grimmia*' (J.D. Hooker 1867, cited in Allen 1987a). He also noted that it might be taken from the type locality, Middle Island (i.e. modern-day South Island of New Zealand) or that it might be a reference to the lateral position of the capsule. However, none of Mitten's other generic names allude to a locality, and Mitten himself considered the perichaetia to be terminal (Allen 1987a: 441), so I think Allen's first suggestion is very likely correct.

Meteoriopsis M.Fleisch. ex Broth. 1906 — *Meteorium* + *opsis* (similar to), reflecting its segregation from other genera of Meteoriaceae.

Meteorium (Brid.) Dozy & Molk. 1848 — *meteoron* (high in the air), clearly alluding to its dangling epiphytic habit. The name was coined by Bridel (1827: 264) for a subgenus of *Pilotrichum*, but he did not indicate the etymology directly.

Microbryum Schimp. 1860 — *mikros* (small) + *bryon* (moss), alluding to the minute size of the plants: 'in genere nostro species unica caule utitur revera brevi, sed distinctissimo millimetrum fere metiente' (Schimper 1860: 10).

Mielichhoferia Nees & Hornsch. 1831 — After Mathias Mielichhofer (1772–1847), Austrian mineralogist and botanist and friend of Hornschuch. Mielichhofer studied the mosses of the Salzburg Alps between 1799 and 1820.

Mittenia Lindb. 1863 — After William Mitten (1819–1906), English pharmacist in Sussex and later bryologist at Kew. He published many new genera and species of mosses and liverworts, and his private herbarium of some 54,000 specimens was purchased for £400 by the New York Botanical Garden soon after his death (Fleming & Barneby 1964). Sextus Lindberg proposed the name *Mittenia* as a substitute for *Mniopsis* Mitt. (1859),

a later homonym of *Mniopsis* Dumort. (1822) and *Mniopsis* Mart. (1823 or 1824).

Mitthyridium H.Rob. 1975 — *Mitten* + *Thyridium*, a clever combination made by Robinson because *Thyridium* Mitten (1968) was illegitimate as a later homonym of *Thyridium* Nitschke (1967), a genus of fungi (Robinson 1975: 432). The name *Thyridium* is from *thyris* (little door, window). Although not specifically stated by Mitten, the name clearly alludes to the group of thin-walled hyaline cells (cancellinae) in the leaf base: '*Thyridium* differs in its creeping stems and in the structure of its leaves being similar to that of *Calymperes* and *Syrrhopodon*' (Mitten 1868: 188).

Muelleriella Dusén 1905 — After Carl Müller (see *Muellerobryum*). The name is conserved over *Muelleriella* von Huerck 1896, a genus of diatoms.

Muellerobryum M.Fleisch. 1905 — After Carl Johann August Müller (1818–1899), renowned bryologist in Halle, who had published the illegitimate (later homonym) name *Armitia* for this genus: 'Sie ist dem Andenken des †Bryologen Carl Müller-Halle gewidmet' (Fleischer 1905–06: 62).

Myurium Schimp. 1860 — *myourus* (mouse's tail), alluding to the tail-like extension of the leaf apex: 'Folia valde concava subcochleariformis subito in apiculum filiformem producta.' (Schimper 1860: 695). Unusually for him, Schimper did not indicate the etymology, but *Myurella* Bruch & Schimp. was named on account of the resemblance of the branches to a mouse's tail ('Nomen ob ramorum formam, caudam Musculi imitatem') (Schimper 1860: 484).

Nanobryum Dixon 1922 — *nano* (dwarf) + *bryon* (moss), alluding simply to the very small size of the plants.

Nanomitriopsis Cardot 1909 — *Nanomitrium* + *opsis* (similar to), alluding to the similarity to that genus, whose names is derived from *nanos* (small) + *mitrion* (little cap), alluding to the small operculum: 'Capsula globosa...operculo indistincto' (Cardot 1909: 18). Cardot was probably aware that the name *Nanomitrium* had already been published by Sextus Lindberg in 1874 for a genus of Ephemeraceae.

Neckera Hedw. 1801 — A name honouring Noël Martin Joseph de Necker (1729–1793), Belgian botanist and bryologist in Mannheim (Dixon 1954), author of numerous important works including *Methodus Muscorum per Clases, Ordines, Genera ac Species* (1771). The genus was named by Hedwig in 1782 as *Neckeria*, an orthographic error that he corrected in 1801 (Britton 1905: 4). The name is conserved against *Nekeria* Scop. 1754 (Papaveraceae). Necker's birth date is often stated to be 1730, but he was born in Lille on 25 December 1729 (hence his first name).

Neckeropsis Reichardt 1870 — *Neckera* + *opsis* (similar to), reflecting the similarity to that genus, from which it was separated, with *Neckera undulata* Hedw. as the type: 'Ich habe desswegen für diese Gattung den Namen *Neckeropsis* wegen ihres *Neckeren* artigen Habitus gewählt und stelle sie zu den *Pilotricheen*.' (Reichardt, in Fenzl 1870: 181).

Neolindbergia M.Fleisch. 1908 — *neo* (new) + *Lindbergia*, honouring Sextus Otto Lindberg (1835–1889), Swedish bryologist and director of the botanical gardens in Helsingfors (Helsinki). 'Die Gattung ist dem Andenken des bekannten Bryologen S. O. Lindberg gewidmet.' (Fleischer 1908: 727). The name *Lindbergia* was not available as it had been published by Kindberg in 1897.

Notoligotrichum G.L.Sm. 1971 — *notos* (south) + genus *Oligotrichum*, alluding to the southern distribution of the species and their separation from *Oligotrichum*, a name derived from *oligos* (few, little) + *tricho* (hair), in reference to the sparse hairs on the calyptra.

Ochiobryum J.R.Spence & H.P.Ramsay 2005 — 'It is named in honour of the late Harumi Ochi (1920–2001), acknowledged expert on *Bryum*, who discussed the two species in one of his papers...' (Spence & Ramsay 2005: 70).

Octoblepharum Hedw. 1801 — *octos* (eight) + *blepharis* (eyelash), alluding to the eight-toothed peristome (Bridel 1826–27: 136). The name was first coined (as *Octoblepharis*) by Johann Schreber in the 8th edition of Linnaeus' *Genera Plantarum* in 1791 (Müller 1848: 86).

Oedicladium Mitt. 1868 — *oideos* (swollen) + *klados* (branch), from the swollen appearance of the leaves: 'Folia undique turgide imbricata' (Mitten 1869: 194).

Oligotrichum A.DC 1805 — *oligos* (few, little) + *triche* (hair), alluding to the sparse hairs on the calyptra: 'la coiffe n'est hérissée que d'un petit nombre de poils' (de Lamarck & de Candolle 1805: 492). The name is conserved under the *Code*.

Orthodicranum (Bruch & Schimp.) Loeske 1910 — *orthos* (upright) + genus *Dicranum*, alluding to the more or less erect capsules. Bruch and Schimper coined the name in the index to volume 1 of *Bryologia Europaea*, but used the name *Orthocarpa* for the section in the treatment (Bruch *et al.* 1836–51: 28), as did Schimper (1860: 80).

Orthodontium Schwägr. 1827 — *orthos* (upright) + *odontos* (toothed), alluding to the upright peristome teeth: 'Peristomium duplex erectum, dentibus sedecim; interioribus basi connatis, erectis.' (Schwägrichen 1827: 123). Schwägrichen (1824: 23) had earlier named another genus *Orthodon* for the same reason.

Orthomnion Wilson 1857 — *orthos* (upright) + *mnion* (moss), alluding to the erect habit, resembling that of *Mnium*, and perhaps also the upright peristome teeth of one of the species, *O. trichomitrium* Wilson. The authorship of the name is sometimes attributed to Mitten, but the title of the paper makes it clear that the names are attributable to William Wilson, and the name was validly published, although with the briefest imaginable diagnosis: 'Perist. *Brachymenii*, habitus *Mnii*, capsula ovali subsymmetrica.' (Mitten & Wilson 1857: 368).

Orthorrhynchium Reichardt 1868 — *orthos* (upright) + *rrhynchos* (beak), alluding to the beak of the operculum: 'operculum rectirostre' (Reichardt, in Fenzl 1870: 181).

Orthotheciella (Müll.Hal.) Ochyra 1998 — Genus *Orthothecium* + Latin diminutive suffix *–ellus*, alluding to the similarity of the habit of *Hypnum* (*Orthotheciella*) *filum* Müll.Hal.) to *Orthothecium strictum* Lorentz: 'Species maxime peculiaris perpulchra, ex habitu Orthothecio stricto Lrtz. valde similis' (Müller 1884: 83). Carl Müller coined the name in 1884 for a section of *Hypnum*, but without a diagnosis, an error he corrected five years later (Müller 1889: 36).

Orthothecium Schimp. 1852 — *orthos* (upright) + *thekion* (little vessel, container), alluding to the erect capsule: 'Nomen…ob capsulam in pedicello erectam' (Schimper 1860: 522). The name is conserved against *Orthothecium* Schott & Endl. 1832 (Sterculiaceae).

Orthotrichum Hedw. 1801 — *orthos* (upright) + *trichos* (hair), alluding to the more or less erect hairs on the capsules of most species.

Palamocladium Müll.Hal. 1896 — *palame* (palm of the hand) + *klados* (branch), alluding to the fasciculate branching: 'caulis fasciculatim in ramulos robustos curvulos pallescentes divisis' (Müller 1896: 466). Carl Müller coined the name to replace *Pleuropus* Griff., a later homonym of the fungal genus *Pleuropus* Pers.

Papillaria (Müll.Hal.) Lorentz 1864 — Latin *papilla* (nipple) + *aris* (resembling), alluding to the papillae (nipple-like projections) on the surface of the cells: 'cellulis punctulatis papillosis composita' (Müller 1851: 134). The name is conserved against *Papillaria* J.Kickx f. 1835, a lichen genus. *Papillaria* Dulac 1867 (Juncaginaceae) is a later homonym but has been synonymised under *Scheuchzeria* L.

Papillidiopsis (Broth.) W.R.Buck & B.C.Tan 1989 — *Papillidium* + *opsis* (similar to), alluding to the similarity to that genus. The name *Papillidium* is from *papillidion* (little nipple), referring to the papillae on the cells. The name was first applied by Brotherus (1905–09: 1119) to a section of the genus *Trichosteleum*.

Pelekium Mitt. 1868 — *pelekys* (axe), presumably from a fancied resemblance of the sporophyte and its seta to a long-handled axe. The name is conserved against *Lorentzia* Hampe 1867.

Pendulothecium Enroth & S.He 1991 — *pendulos* (hanging) + *thekion* (little vessel, container), alluding to the 'cernuous to pendulous' capsules, one of the features that distinguishes the genus from *Homalia* and *Porotrichum*, from which its species were transferred (Enroth & He 1991: 9).

Phascopsis I.G.Stone 1980 — *Phascum* + *opsis* (similar to), alluding to the similarity to that genus.

Phascum L. ex Hedw. 1801 — *phascon*, an ancient name for *Usneam barbatam* of Theophrastus, but applied by Hedwig to all mosses lacking an operculum (Bridel 1826–27: 21, Müller 1848: 23).

Philonotis Brid. 1827 — *philo* (loving) + *notis* (moisture), alluding to the typically moist habitat: 'cum totus hocce genus locis udis scaturiginosis gaudeat' (Bridel 1827: 15).

Physcomitrella Bruch & Schimp. 1849 — Genus *Physcomitrium* + Latin diminutive suffix *–ellus*, alluding to the similarity to that genus: 'Genus *Physcomitrio* et praeprimis *Aphanoregmati* exotico affine' (Schimper 1860: 9).

Physcomitrium (Brid.) Brid. 1827 — *physce* (bladder) + *mitrion* (little cap), probably alluding to the shape of the operculum — 'operculo convexo mammillato' (Bridel 1826–27: 97) and not, as Dixon (1954: 297) suggested, to the calyptra, which Bridel did not describe. Bridel first used the name as a subgenus of *Gymnostomum* (Bridel 1826–27: 97) in volume 1 of his *Bryologia Universa*, but it was raised to the rank of genus in the index to volume 2 (Bridel 1827: 815).

Pinnatella M.Fleisch. 1906 — Latin *pinnata* (feathered) + diminutive suffix *–ellus*, alluding to the small, regularly pinnate secondary shoots arising from a creeping primary stem. The name was coined by Carl Müller (1875: 456) as a section of *Hypnum* but without a diagnosis.

Plagiobryum Lindb. 1862 — *plagios* (oblique) + *bryon* (moss), 'from the incurved capsule' (Dixon 1954: 341).

Plagiomnium T.J.Kop. 1968 — *plagios* (oblique) + *mnion* (moss), alluding to the presence of plagiotropic stolons in most species, a feature which distinguishes the genus from *Mnium* (Koponen 1968: 145).

Plagiothecium Bruch & Schimp. 1851 — *plagios* (oblique) + *thekion* (little vessel, container), alluding to the typically obliquely angled capsule: 'Capsula…plus minusque obliquata (unde nomen, πλαγιος obliquus)' (Schimper 1860: 575).

Platyhypnidium M.Fleisch. 1923 — Diminutive of *Platyhypnum*, the name given to the genus by Loeske in 1911 but already applied to another group of mosses by Hampe in 1877 (Fleischer 1923: 1537). Fleischer therefore felt that the new name *Platyhypnidium* was appropriate. The original name comes from *platys* (flat, wide) + *hypnon* (moss), alluding to the prostrate, spreading habit.

Pleuridium Brid. 1819 — *pleuridion* (on one side), indicating that the capsule is lateral, or apparently so: 'ob thecam lateralem aut talem visam, nomen istud confecimus' (Bridel 1827: 160). William Mitten felt that the name was 'neither founded on a true idea of their mode of fruiting nor applicable to the species' (Mitten 1851: 306). The name is conserved against *Pleuridium* Brid. 1818.

Pleurophascum Lindb. 1875 — *pleuron* (rib, side) + genus *Phascum*, alluding to the deeply plicate leaves of the type species, *P. grandiglobum* Lindb.

Pogonatum P.Beauv. 1804 — *pogonatos* (bearded), alluding to the densely hairy calyptra: 'Coeffe… l'extérieure composée de filamens entrelacés' (Palisot de Beauvois 1804: 329).

Pohlia Hedw. 1801 — After Johann Ehrenfried Pohl (1746–1800), professor of botany at Leipzig University where Hedwig was professor of medicine until 1789. In that year Pohl moved to Dresden and Hedwig was awarded his position, which included directorship of the botanical garden (Florschütz 1960). Hedwig first coined the name in 1789 (Hedwig 1801). The name has been mistakenly identified with a number of other Pohls (e.g. Koperski 1991), including Johann Emanuel Pohl (1782–1834), Austrian botanist in South America.

Polytrichadelphus (Müll.Hal.) Mitt. 1859 — genus *Polytrichum* + *adelphos* (brother), alluding to the similarity to that genus. Müller (1848: 201) coined the name for a section of *Catharinea* in which he included two species previously placed in *Polytrichum*, *C. ciliata* Müll.Hal. and *C. magellanica* Brid. Mitten (1859b: 97) raised the section to generic rank but included only the latter species, along with two others transferred from *Polytrichum*.

Polytrichastrum G.L.Sm. 1971 — *Polytrichum* + Latin *astrum* (star), probably reinforcing the star-like form of the plants when viewed from above.

Polytrichum Hedw. 1801 — *polys* (many) + *trichos* (hair), alluding to the hairy calyptra. The name had been in use since ancient times (*polytrichon*), but Johann Dillen first used it in its modern sense in 1718 (Scott 1988: 10).

Porothamnium M.Fleisch. 1908 — a combination of *Porotrichum* + *Thamnium*, alluding to two of the four genera from which Max Fleischer transferred species to create the new genus, the others being *Neckera* and *Leskea*. *Porotrichum* is derived from *poros* (perforation, passage, tube) + *triche* (hair), alluding to the perforated processes of the inner peristome (Dixon 1954: 409).

Pottia Ehrh. ex Fürnr. 1829 — After Friedrich Johann Pott (1738–1805), professor of botany at Braunschweig. Friedrich Ehrhart (1742–1795) first published the name in 1787, before the starting date for moss nomenclature. The name is conserved against *Anacalypta* Röhl. ex Leman 1816 and *Physedium* Brid. 1826.

Powellia Mitt. 1868 — After Thomas Powell (1803–1887), missionary and botanist in the South Pacific, mainly in Samoa. He collected the type of the genus, *Powellia involutifolia* Mitt., from the base of a coconut palm on Tutuila (Mitten 1868: 188).

Pseudephemerum (Lindb.) I.Hagen 1910 — *pseudo* (false) + *Ephemerum*, indicating the similarity to that genus.

Pseudohypnella (Broth.) M.Fleisch. 1923 — *pseudo* (false) + genus *Hypnella* (diminutive of *Hypnum*), presumably from a resemblance to that genus. Brotherus first applied the name to a section of *Taxithelium*.

Pseudoleskeopsis Broth. 1907 — *Pseudoleskea* + *opsis* (similar to), alluding to the similarity to that genus. The name *Pseudoleskea* refers to the resembles the similarity to the genus *Leskea*, a name honouring Nathanael Gottfried Leske (1751–1786), professor in Leipzig and Marburg. Leske was a contemporary of Johann Hedwig, who coined the name *Leskea* in 1782 (Crum & Anderson 1981, Koperski 1991).

Pseudoscleropodium (Limpr.) M.Fleisch. ex Broth. 1925 — *pseudo* (false) + genus *Scleropodium*, alluding to Limpricht's original subgeneric separation of *S. purum* on the grounds of a smooth seta, pinnate branching and more or less plicate leaves. Limpricht (1895–1903: 142).

Pseudospiridentopsis (Broth.) M.Fleisch. 1908 — *pseudo* (false) + genus *Spiridentopsis*, alluding to the similarity to that genus. Brotherus created the name for a section of *Trachypodopsis*, and Max Fleischer raised it to generic rank with one species, *P. horrida* (Mitt.) M.Fleisch., on the basis that the peristome structure and habit was different from those of all other sections of *Trachypodopsis* (Fleischer 1908: 730).

Pseudosymblepharis Broth. 1924 — *pseudo* (false) + genus *Symblepharis*, alluding to the similarity in appearance to that genus. The latter name is derived from *sym-* (joined) + *blepharis* (eyelash), referring to the peristome teeth: 'the sixteen teeth of the peristome are more or less completely united below in pairs, and so form eight groups' (Salmon 1898: 486).

Pseudotaxiphyllum Iwats. 1987— *pseudo* (false) + *Taxiphyllum*, alluding to the similarity in growth form to species in that genus. Zennoske Iwatsuki first coined the name for a subgenus of *Isopterygium*, but without a diagnosis (Iwatsuki 1970: 334). He made the separation of *Pseudotaxiphyllum* on the basis of the lack of paraphyllia, the presence of gemmae, the dioicous condition and the presence of an annulus on the capsule (Iwatsuki 1987: 448).

Psilopilum Brid. 1827 — *psilos* (bare, bald) + *pilos* (felt hat), alluding to the lack of hairs on the calyptra: 'e calyptrae glabritie desumptum' (Bridel 1827: 95).

Pterobryella (Müll.Hal.) A.Jaeger 1877 — *pteron* (wing, feather) + *bryon* (moss) + Latin diminutive suffix *-ellus*, alluding to the feathery habit: 'frons dendroideus pteroidea = vel climacioideo = plumosus' (Müller 1873: 182). The name was originally coined for a section of *Hypnum* by Carl Müller (the names *Pterobryum* and *Pterobryon* were already in use)and later raised to generic rank by August Jaeger.

Pterobryidium Broth. & Watts 1918 — Genus *Pterobryopsis* + Greek diminutive suffix *–idion*, alluding to the similarity to that genus: 'Genus novum insigne, habitu foliorumque structura speciebus nonnullis *Pterobryopsidis* simillimum...' (Brotherus & Watts 1918: 559).

Pterobryon Hornsch. in Mart. 1840 — *pteron* (wing, feather) + *bryon* (moss), alluding to the neat pinnate branching: 'Nomen ob ramulos eleganter pinnatos, e vocius πτερον, ala, et βρυον, muscus, compositum.' (Hornschuch, in Martius 1840: 51).

Pterygoneurum Jur. 1897 — *pterygion* (little wing) + *neuron* (nerve), alluding to the wing-like lamellae on the dorsal side of the costa. The name is conserved against *Pharomitrium* Schimp. 1860.

Ptychomitrium Fürnr. 1829 — *ptyche* (pleat) + *mitrion* (little cap), alluding to the plicate calyptra: 'Nomen *Ptychomitrium* a nobis in *Bryol. eur.* propositum caracterem (πτυχη, plica, μιτριον, calyptra) omnibus speciebus necessarie communem exprimit.' (Schimper 1860: 243). The name is conserved against *Brachysteleum* Rchb. 1829.

Ptychomnion (Hook.f. & Wilson) Mitt. 1869 — *ptychos* (pleated) + *mnion* (moss), alluding to the pleating of the leaves (especially when dry) and probably also the plicate theca: 'Folia plicata, e celluis angustis pellucidis areolata. Thecae plicatae.' (Mitten 1869: 536).

Pulchrinodus B.H.Allen 1987 — Latin *pulchre* (beautifully) + *nodus* (knot, difficulty). 'The name is given in reference to the striking beauty of this moss and the puzzling systematic problem it presents.' (Allen 1987b: 340). Bruce Allen was referring in the second instance to the doubtful placement of the genus in the Pterobryaceae.

Pyrrhobryum Mitt. 1868 — *pyrrhos* (fire-coloured) + *bryon* (moss), presumably alluding to the colour of the peristome, although Mitten (1868: 174) did not indicate the etymology.

Racomitrium Brid. 1819 — *rhakos* (frayed) + *mitrion* (little cap), alluding to the calyptra, which in some species is split all around the base: 'Nomen a graecâ voce ρακος lacer et μιτριον ob calyptram basi lacero-fimbriatam.' (Bridel 1826–27: 208). Bridel preferred to omit the aspirated *h*.

Racopilum P.Beauv. 1805 — *rhakos* (frayed) + *pilos* (felt hat), alluding to 'a ragged and hairy cap... more appropriate to those species with mitrate, lobed calyptra' (Crum & Anderson 1981: 877). As in *Racomitrium*, the aspirated *h* was omitted from the original name.

Radulina W.R.Buck & B.C.Tan 1989 — *Radula* (a scraper); 'the generic name is derived from Latin for a small scraper, and by extension to a snail's tongue, in reference to the leaf papillae' (Ramsay *et al.* 2004). It is interesting to compare this etymology with that of the liverwort genus *Radula*, which alludes to the flattened, truncate perianth.

Rhabdodontium Broth. 1906 — *rhabdosis* (fluting of a column) + *odontos* (toothed), alluding to the striate, lamellate peristome teeth: 'mit zickzackförmiger Längslinie, bis über die Mitte quer- und schrägstreifig, and der Spitze hyalin, spärlich papillös, ohne vortretende Lamellen.' (Brotherus 1905–09: 804).

Rhacocarpus Lindb. 1863 — *rhakos* (frayed) + *karpos* (seed), presumably alluding to the raggedly split base of the calyptra. Magill (1993: 10) provided a neat summary of the intrigue surrounding the conservation of this name.

Rhaphidorrhynchium Besch. ex M.Fleisch. 1923 — *rhaphidos* (needle-like) + *rhynchos* (bill, beak), alluding to the long, narrow rostrum on the operculum. Bescherelle coined the name in his *Note sur les Mousses des iles Saint-Paul et d'Amsterdam* (1875: 3, 5) (Fleischer 1923: 1245), but apparently that has not been accepted as valid publication of the name.

Rhizogonium Brid. 1827 — *rhiza* (root) + *gonima* (fruit), alluding to the fact that the sporophytes appear to arise from the 'root' of the plant — 'originem ab ipsa radice in hoc genere solemnem indicans' (Bridel 1827: 663) — although they are actually borne on specialized branches at the base of the stem. Crum and Anderson (1981: 657) were not quite correct in suggesting that the name referred to the 'copious paraphyses, suggesting a rooted sporophyte'. The stem *gonima* was misspelt *ginomai* in the protologue.

Rhodobryum (Schimp.) Limpr. 1892 — *rhodon* (rose) + *bryon* (moss), from the terminal rosette of leaves in most of the species: 'Folia...comalia in rosulam patula (unde nomen) congesta' (Schimper 1860: 381). Schimper created the subgenus *Rhodobryum* within *Bryum* to accommodate *B. roseum* (Hedw.) Crome, and Limpricht raised it to generic rank. The name is conserved against *Rhodo-bryum* Hampe 1874.

Rhynchostegium Bruch & Schimp. 1852 — *rhynchos* (bill) + *stegeon* (roof, covering), alluding to the long-beaked operculum: 'operculum subulirostrum' (Schimper 1860: 564).

Rhytidiadelphus (Limpr.) Warnst. 1906 — *Rhytidium* + *adelphus* (brother), alluding to the supposedly close relationship between the two genera (originally both subgenera of *Hylocomium*). Limpricht (1895–1903: 590) published the name, citing Lindberg (1879) as the authority, but Lindberg apparently published the name without description.

Rosulabryum J.R.Spence 1996 — 'Latin *rosula* (a rosette) and Greek *bryon* (a moss), in reference to the leaves being clustered in rosettes' (Spence & Ramsay 2006). Spence erected the genus to include the rosulate species of *Bryum* with unreduced peristomes (Spence 1996: 222).

Saelania Lindb. 1878 — A name honouring Anders Thiodolf Saelan (1834–1921), Finnish psychiatrist and botanist in Helsingfors (Helsinki). For a short time he was an assistant at the museum in Helsinki and worked with William Nylander on the botanical collections of the museum. For most of his life he devoted himself to psychiatric medicine, but compiled (with Elia Lönnrot) the first flora of Finland written in Finnish as well a complete bibliography of Finnish botanical literature (Westrin *et al.* 1926: 157–158).

Sanionia Loeske 1907 — After Carl Gustav Sanio (1832–1891), Prussian botanist and teacher in Lyck. Sanio, along with Limpricht and Warnstorf, worked on mosses included at some stage in *Drepanocladus*, and Loeske honoured all three in the names of genera constituted in part from species of *Drepanocladus* (Loeske 1907: 309). Sanio is best known for his work on wood anatomy, particularly the nature of compression wood.

Sauloma (Hook.f. & Wilson) Mitt 1860 — *saulos* (soft). Although Wilson (1854: 122) gave this etymology for his new section of *Hookeria* he did not explain it, but it presumably alludes to the soft, delicate appearance of *Sauloma tenella* (Hook.f. & Wilson) Mitt.

Schistidium Brid. 1819 —*schistos* (divided) + Greek diminutive suffix *–idion*, alluding to the splitting of the calyptra at its base (Bridel 1826–27: 113). The name is conserved against *Schistidium* Brid. 1818.

Schizymenium Harv. ex Hook. 1840 — *schizos* (split) + *hymenium* (an old name for the peristome), alluding to the inner peristome which is divided into branched cilia above a low basal membrane: 'Peristomium simplex; membrana horizontalis ex integumento interno orta, in ciliosis subtilibus subramosis fissa.' (W.J. Hooker 1840: t. 202). Hooker was incorrect in believing that the peristome was single, as an outer peristome is often present in the type species, *S. bryoides* Harv. ex Hook.

Schlotheimia Brid. 1812 — A name honouring Ernst Friedrich von Schlotheim (1764–1832), an aquaintance of Bridel: 'Nomen huic generi in honorem viri generossimi, clarissimi, amicissimi a Schlotheim, naturae sagacissimi investigatoris, impositum' (Bridel 1826–27: 329).

Schoenobryum Dozy & Molk. 1848 — *schoinos* (cord, reed) + *bryon* (moss), alluding to the cord-like appearance of the stems, especially when dry: 'Nomen huicce generi impositum est, a Graecis verbis σχοινος et bryon βρυον, propter caules praesertim siccitate funiformes' (Dozy & Molkenboer 1848: 184).

Schwetschkea Müll.Hal. 1875 — After (Carl) Gustav Schwetschke (1804–1881), bookseller (and probably publisher) in Halle where Müller lived, in celebration of Schwetschke's 50th anniversary —'in welcher der Buchhandler Dr. Gustav Schwetschke in Halle a. S. sein fünfzigjähriges Jubiläum feirte' (Müller 1875: 429). Schwetschke is known largely as the author of the *Codex Nundinarius Germaniae Literatae Bisecularis* of 1850–1877, a bibliography of all the Frankfurt and Leipzig book fairs from 1564 to 1846.

Sclerodontium Schwägr. 1824 — *skleros* (hard, rough) + *odontos* (toothed), alluding to the roughened surface of the peristome teeth: '*Peristomium* simplex coriaceum' (Schwägr. 1824: 124).

Scleropodium Bruch & Schimp. 1853 — *skleros* (hard, rough) + *pous* (foot), alluding to the papillose seta: 'pedicello aspero (unde nomen, σκληρος asper)' (Schimper 1860: 546).

Scorpidium (Schimp.) Limpr. 1899 — *scorpio* (scorpion) + diminutive suffix *–idion*, alluding to 'a resemblance to a scorpion with its tail curved upwards' (Crum & Anderson 1981: 994) in relation to the generitype, *S. scorpioides* (Hedw.) Limpr. This resemblance was first suggested by Johann Dillen, who coined the name *Hypnum scorpioides* (= *S. scorpioides*) (Dillen (1741: 290).

Scorpiurium Schimp. 1876 — *scorpiouros* (scorpion's tail), alluding to the combination of falcate-secund leaves and drooping capsule, giving a fancied resemblance to a scorpion with its tail raised.

Seligeria Bruch & Schimp. 1846 — After Ignaz Seliger (1752–1812), pastor and botanist in Wölfelsdorf, Silesia (now Wilkanów, Poland). 'zu Ehren des schlesischen Botanikers Pfarrer Seliger bennant' (Müller 1901: 305). Bruch and Schimper (1846: 7) based the name on *Weissia seligeri*, a synonym of *Weissia pusilla*, the generitype of the new genus.

Sematophyllum Mitt. 1864 — *semato* marked + *phyllon* leaf, alluding without doubt to the distinctive alar cells that distinguish the genus: '*Folia* cellulis alaribus utplurimum utrinque tribus distinctis signata.' (Mitten 1864: 5).

Sorapilla Spruce & Mitt. 1869 — From the word for 'moss' as spoken by the people ('Indos Maynenses') of the foothills of the eastern Andes (Spruce in Mitt. 1869: 603).

Sphagnum Linnaeus 1753 — *sphagnos*, an ancient name applied by Pliny to a lichen or moss, and by Johann Dillen to this genus, then ratified by Linnaeus and Hedwig (Bridel 1926–27: 1).

Spiridens Nees 1823 — *speiros* (spiralled, twisted) + Latin *dens* (tooth), alluding to 'the spirally involute nature of the teeth of the peristome, as seen when dry' (Hooker 1830: 2).

Splachnobryum Müll.Hal. 1869 — 'So named because of a presumed relationship to the Splachnaceae and some resemblance in habit to some blunt-leaved species of *Bryum*.' (Crum & Anderson 1981). The genus name *Splachnum* comes from *splachnos* (viscera), alluding to the rugose appearance of the apophysis when dry, and was in use before Johann Dillen published it (Scott 1987: 625). Crum and Anderson (1981) mistakenly gave the meaning as 'lunglike'.

Stereophyllum Mitt. 1859 — *stereos* (stiff, solid) + *phyllon* (leaf), presumably alluding to the stiffness of the leaves. Mitten created the genus to include a single species, *S. indicum* (Bél.) Mitt. Unfortunately he did not give a description of that species, and his generic diagnosis is remarkably brief: 'Pleurocarpium. Folia uninervis, cellulis rotundatis firmis. Caulis prostratus, vage ramosus, radicans.' (Mitten 1859a: 117).

Stonea R.H.Zander 1989 — After Ilma Grace Stone (1913–2001), Australian bryologist in Melbourne. She is best known for co-authoring *The Mosses of Southern Australia* (Scott & Stone 1976) and her detailed studies on *Fissidens* and Pottiaceae. She named three extant Australian genera: *Calymperastrum*, *Phascopsis* and *Viridivellus* and has two Australian moss species named in her honour: *Macromitrium stoneae* Vitt & Ramsay, and *Syrropodon stoneae* Reese,

Stoneobryum Norris & H.Robinson 1981 — 'We name the new genus *Stoneobryum* in honour of Dr. Ilma Stone of the University of Melbourne, Australia' (Norris & Robinson 1981: 96). See *Stonea*.

Straminergon Hedenäs 1993 a combination of the specific epithet of the type species *Hypnum stramineum*, from Latin *stramineus* (straw-like), and the similarity to *Calliergon* — 'speciebus *Calliergonis* (Sull.) Kindb. simile' (Hedenäs 1993: 462).

Syntrichia Brid. 1801 — *syn* (together, joined) + *trichos* (hair), alluding to the attachment of the bases of the hair-like peristome teeth to the inner membrane: 'ob cilia [seu] dentes capilliformes basi in membranae contextos' (Bridel 1826–27: 578).

Syrrhopodon Schwägr. 1824 — *syrrhopos* (close together) + *odon* (tooth), alluding to the connivent

teeth of the peristome: 'Nomen a dentibus peristomii conniventibus fere horizontalibus, συρροποζ' (Schwägrichen 1824: 110).

Taxiphyllum M.Fleisch. 1923 — apparently from Latin *taxus* (yew) + *phyllon* (leaf), derived downwards from section *Taxicaulis* of *Hypnum* erected by Müller (1851: 277). Müller coined *Taxicaulis* seemingly in apposition to section *Cupressina*, a name clearly derived from *Cupressus* on account of the appearance of the stems, noting 'Caulis tenellus plumulose foliosus...a *Cupressinae* congeneribus foliis oblique acuminatis (ut rami) vix falcatis' (Müller loc. cit.). Mitten's name *Stereodon* (*Taxiphyllum*) *taxirameum* further reflects this presumed etymology. Because the leaves in *Taxiphyllum* are more or less two-ranked, it has been claimed that the first stem is Greek *taxis* (arrangement, rank). However, the more instructive (and available) *Ditaxiphyllum* would have been a logical choice of name had that been the intention.

Taxithelium Spruce ex Mitt. 1869 — *taxis* (arrangement, rank) + *thele* (nipple), 'so named because of several papillae arranged in a row over the cell lumen (in some species)' (Crum & Anderson 1981: 1123).

Tayloria Hook. 1816 — After Irish botanist Thomas Taylor (1775–1848), who collaborated with William Hooker on *Muscologica Britannia*.

Tetracoscinodon R.Br. bis. 1895 — *tetra* (four) + *Coscinodon*, presumably alluding to the four-toothed peristome and the similarity in appearance to that genus.

Tetraphidopsis Broth. & Dixon 1912 — genus *Tetraphis* + *opsis* (similar to), alluding to the similarity to that genus: 'the capitulum is enclosed in bracts resembling those of *Tetraphis* but smaller' (Dixon 1912: 453). The name *Tetraphis* was coined by Johann Hedwig, from *tetraphos* (divided into four parts) — not *tetra* (four) as is often stated — referring to the four peristome teeth: 'Peristomium simplex, dentibus quatuor pyramidalibus.' (Hedwig 1801: 45).

Tetrapterum Hampe ex A.Jaeger 1869 — *tetra* (four) + *pteron* (wing, feather). 'The generic name, applied because the spore capsule was regarded as quadrangular rather than rounded in section, goes back to Hampe (*in litt.*) according to Carl Müller.' (Andrews 1945: 190).

Thamnium Schimp. 1852 — *thamnion* (bush, shrub), alluding to the rather untidy, bushy appearance of the plants: 'nomine faciem suam (θαμνιον arbuscula) declarante designatum' (Schimper 1860: 574). The name is illegitimate (see *Thamnobryum*) and stands in the Australian flora only because *T. novaevalesiae* Kindb. has not been transferred. The genus once comprised almost 100 disparate species.

Thamnobryum Nieuwl. 1917 — *Thamnium* + *bryon* (moss), a replacement for *Thamnium*, an illegitimate name because of an earlier homonym: 'Because there was an older *Thamnium* Klotsch the moss of that name must receive another. *Thamnobryum* may be suggested.' (Nieuwland 1917: 50).

Thuidiopsis (Broth.) M.Fleisch. 1923 —*Thuidium* + *opsis* (similar to), a simple name variation coined by Brotherus (1905–09: 1014) for a subgenus of *Thuidium* and raised to generic rank by Fleischer.

Thuidium Bruch & Schimp. 1852 — Genus *Thuja* (Cupressaceae) + Greek diminutive suffix *–idion*, alluding to the resemblance of the feathery, branched fronds to the foliage of those trees: 'Le genre *Thuidium*, ainsi nommé à cause du port des plantes qu'il renforme et qui imitent en petit celui des *Thuia*' (Bruch *et al.* 1851–55: 157). Dixon (1954: 424) was correct in stating that the name was not, as Sextus Lindberg thought, derived from *thya* (door, gate). The name *Thuja* is probably a corruption from the *thya* of Theophrastus, from the Greek verb *thyo* (I perfume), alluding to the use of cedar wood as incense (Phillips 1823: 51).

Timmia Hedw. 1801 — A name honouring Joachim Christian Timm (1734–1805), German botanist and mayor of Malchin, author of *Florae Megapolitanae Prodromus* (1788). 'Nominis ratio. Cl. Timm., Consul apud Malchinenses meritissimus simulque vegetabilium cuiusque generis in illis terris prouenientium indefessus indagator, primus singularem hanc speciem ibidem detexit, mihique cespitibus recentibus transmissis, eandem vertim disquirendi fecit copiam.' (Hedwig 1787: 85). The type of the genus is, appropriately, *Timmia*

megapolitana Hedw. The name is conserved against *Timmia* J.F.Gmel. 1791 (Amaryllidaceae).

Tortella (Lindb.) Limpr. 1888 — Latin *tortus* (twisted) + diminutive suffix *–ellus*, alluding to the characteristic twisting of the long peristome teeth: 'Peristomäste (32) spiralig links gewunden' (Limpricht 1888: 520). Lindberg (1879: 21) coined the named for a subgenus of *Mollia* Schrank ex Lindb.

Tortula Hedw. 1801 — Diminutive of Latin *tortus* (twisted), from the spiral twisting of the peristome teeth: 'Peristomium simplex: dentibus capillaribus, spiraliter convolutis…' (Hedwig 1801: 122). The name is conserved against *Tortula* Roxb. ex Willd. 1800 (Verbenaceae).

Touwia Ochyra 1986 — 'It is with great pleasure that I name this distinctive genus and species *Touwia laticostata* in honour of Dr Andries Touw of Leiden, Holland, in recognition of his great contribution to the taxonomy of exotic mosses, especially of the Neckeraceae.' (Ochyra 1986: 103).

Trachycarpidium Broth. 1901 — *trachys* (rough) + *karpos* (fruit) + diminutive suffix *–idion*, alluding to the surface of the capsule of the type species, *T. verrucosum* (Besch.) Broth.: 'Kapsel…mit großen Pusteln dicht besetzt' (Brotherus 1901–05: 384).

Trachyloma Brid. 1827 — *trachys* (rough) + *loma* (border), referring to the papillose outer surface of the ciliate peristome teeth: '…ciliorum marginem denticulis asperum denotans' (Bridel 1827: 277).

Trachyphyllum A.Gepp. 1901 — *trachys* (rough) + *phyllon* (leaf), alluding to the papillose surface of the leaves, with papillae at each end of the cells: 'This peculiar type of papillosity, usually coupled with numerous quadrate alar cells, make the genus readily identifiable' (Buck 1979: 379).

Trachypus Reinw. & Hornsch. 1829 — *trachys* (rough) + *pous* (foot), alluding to the markedly papillose seta.

Trachythecium M.Fleisch. 1923 — *trachys* (rough) + *thekion* (little vessel, container), alluding to the surface of the capsule, on the basis of which Fleischer separated the genus from *Ectropothecium*: 'mit grossen, mamillosen Warzen bedeckten Sporogone' (Fleischer 1923: 1415).

Trematodon Michx. 1803 — *tremato* (perforated) + *odon* (tooth), alluding to the perforated peristome teeth: 'Peristomii simplicis dentes 16, distincti, subulati, recti, foraminulis pertusi.' (Michaux 1803: 289). Wilson (1854–55: 69) incorrectly attributed the name to Louis Richard, who helped Michaux's son Francois prepare the volume for publication after Michaux's death.

Trichosteleum Mitt. 1868 — *trichos* (hairy, hair-like) + *stele* (pillar, column), alluding apparently to the long, slender seta: 'Theca in pedunculo elongato gracillimo…' (Mitten 1868: 181).

Trichostomum Bruch 1829 — *trichos* (hairy, hair-like) + *stoma* (mouth), alluding to the filiform peristome. Although attributed to Bruch under the rules of nomenclature, the name was coined by Hedwig: 'Nomen Hedwigianum…ob peristomii dentes angustos capilliformes' Bridel (1826: 488). The name is conserved against *Trichostomum* Hedw. 1810 and *Plaubelia* Brid. 1826.

Tridontium Hook.f. ex Hook. 1840 — *tris* (three) + *odontos* (toothed), alluding to the peristome teeth, which tend to split into three ciliate segments, as illustrated and described by Hooker: 'dentibus… singula e ciliis tribus articulatis magis minusve connexis formata' (W.J. Hooker 1840: t. 248).

Triquetrella Müll.Hal. 1897 — Latin *triquetris* (triangular) + diminutive suffix *–ellus*, alluding simply to the triquetrous arrangement of the leaves. Carl Müller probably used this form because *Triquetra* was already in use for a genus of Fabaceae.

Trismegistia (Müll.Hal.) Müll.Hal. 1896 — Presumably from Hermes Trismegistus ('thrice greatest'), an incarnation of the Egyptian god Thoth and divine bringer of knowledge; no other etymology seems possible. The name was first given by Müller (1874: 89) to a section of *Hypnum* in 1874, without any indication of the etymology.

Uleobryum Broth. 1906 — After Ernst Heinrich Georg Ule (1854–1915), German botanical explorer in Amazonian and Andean South America, + *bryon* (moss). 'Genus novum peregrinatorini meritissimo E. Ule dedicatum' (Brotherus 1906: 271).

Ulota D.Mohr 1806 — *ulote* (something curled), alluding to the strongly curled leaves (when dry) of

most species. Bridel (1826–27: 300) noted that one of the English names for the genus was 'curl-moss'.

Verrucidens Cardot 1908 — Latin *verruca* (wart) + *dens* (tooth), alluding to the warty surface of the peristome teeth. *Verrucidens* was placed under *Dicranoweisia* by Ochyra (1999: 500) but this has not been generally accepted.

Vesicularia (Müll.Hal.) Müll.Hal. 1896 — Latin *vesicula* (little bladder) + *aris* (resembling), alluding to 'the lax areolation of the leaf, consisting of short, broad cells suggestive of inflated vesicles (or bladders)' (Crum & Anderson 1981: 1196). This view is supported by Müller's description of the cells of *Hypnum* [*Vesicularia*] *montagnei* Müll. Hal. — 'cellulis magis chlorophyllosis, utriculo primordiali maxime evoluto saepe densissime repletis tenerrimus' (Müller 1851: 234).

Viridivellus I.G.Stone 1976 — Latin *viridis* (green) + *vellus* (wool, fleece), alluding to the appearance of the only species, *Viridivellus pulchellum* — 'Gametophyte...in patches like tiny green fleece' (Stone 1976). The name was suggested to Ilma Stone by George Scott.

Warburgiella Müll.Hal. ex Broth. 1900 — After botanist Otto Warburg (1859–1938), who studied in particular the flora of the monsoon regions, especially in the Philippines but also the Indian subcontinent, mainland Asia and Australia. His cryptogamic collections were enumerated in the first volume of *Monsunia* (Underwood 1903: 666), in which Carl Müller first published the name *Warburgiella* as a subgenus of *Hypnum*. The African genus *Warburgia* had already been named in Warburg's honour.

Warnstorfia Loeske 1907 — After Carl Friedrich Warnstorf (1837–1921), German teacher and botanist, a contemporary of Leopold Loeske (1865–1935). *Warnstorfia* was constituted from species drawn in part from *Drepanocladus* (see also *Sanionia*).

Weissia Hedw. 1801 — After Friederich Wilhelm Weiss (1744–1826), botanist in Göttingen (Hedwig 1801: 64). His first name was Friederich on his birth certificate but Friedrich on his death certificate, and his surname was Weiß (= Weisz or Weiss) in German but Weis in the Latinised form used in his doctoral dissertation, and presumably subsequently in his professional career (Grummann 1962). Thus *Weissia* is based on his German name but *Dicranoweisia* is based on his Latinised name.

Weymouthia Broth. 1906 — After William Anderson Weymouth (1842–1928) English-born botanical collector in Tasmania. On arriving in Launceston he worked on newspapers, and later became an insurance agent. What little is known of his life has been summarised by Dalton (1997).

Wijkia H.A.Crum 1971 — 'I have chosen the name *Wijkia* as a tribute to the invaluable contribution to bryology made by Dr. R. van der Wijk of Gröningen, chief editor of the *Index Muscorum*.' (Crum 1971: 170).

Willia Müll.Hal. 1890 — A name honouring Hermann Will (1852–1930), German botanist on the South Polar Expedition of 1882–1883 (Godley 1970: 81). Will spent a year on South Georgia during this expedition, and collected the type there (Müller 1890: 311).

Wilsoniella Müll.Hal. 1881 — After William Wilson (1799–1871), English bryologist, author of *Bryologia Britannica* (Wilson 1855) and a major contributor to *Botany of the Antarctic Voyage* (J.D. Hooker 1844–60). The name *Wilsonia* was unavailable to Carl Müller as it had been published for three different vascular genera: *Wilsonia* Raf. 1814, *Wilsonia* R.Br. 1818 and *Wilsonia* Hook. 1829.

Zygodon Hook. & Taylor 1818 — *zygos* (yoke) + *odon* (tooth), alluding to the peristome teeth, which have 'the exterior of 16 teeth approaching in pairs' (W.J. Hooker & Taylor 1818: 70), i.e. as if yoked together.

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New combinations in *Dendrobium* (Orchidaceae)

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Abstract

Molecular phylogenetics of Subtribe Dendrobiinae (Orchidaceae – Epidendroideae) have revealed that *Codetio*, *Diplocaulobium*, *Flickingerio* and *Grastidium* are nested within *Dendrobium* as traditionally circumscribed. We consider that there are compelling reasons, based on evidence and the desirability of nomenclatural stability, to recombine these genera as well as *Euphlebium* and *Epigeneium* (among others) within *Dendrobium*. New combinations are presented where species do not presently have valid *Dendrobium* names.

Keywords: Dendrobiinae, *Flickingerio*, *Codetia*, *Diplocoulobium*, *Epigeneium*

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Introduction

Molecular phylogenies of subtribe *Dendrobiinae* based on chloroplast and nuclear markers consistently show that the commonly accepted genera *Cadetia*, *Diplocaulobium*, *Flickingeria* and *Grastidium* are all nested within one of the two main clades of *Dendrobium* (Yukawa *et al.* 1993, 1996, 2000, 2001; Clements 2003, 2006; Burke *et al.* 2008). Recognition of these genera thus renders *Dendrobium* paraphyletic. This implies that either *Dendrobium* should be split up into many, potentially dozens, of smaller genera (as advocated by Clements and Jones 2002; Clements 2006), or that the four satellite genera mentioned above should be included in a more broadly circumscribed genus *Dendrobium*. We consider the first alternative to be undesirable, and support the second alternative for the following main reasons:

1. At present the phylogenies do not show enough resolution. Beyond the division into two strongly supported clades, Asian and Australasian (Clements 2003), there is no obvious way to split up *Dendrobium* into monophyletic groups. Nodes at intermediate levels of the phylogenetic trees are poorly supported, providing no basis for subdivision. Past hybridisation and other genetic events may have contributed to the current situation where DNA analyses alone do not readily lead to a satisfactory classification.
2. Splitting on the basis of relatively small terminal subclades would necessitate the recognition of numerous genera, many being small or even monotypic. It would make generic identification difficult and error prone.
3. Sampling of most *Dendrobium* sections has been low, with some not studied at all, and the relationships suggested in cladograms may change considerably as sampling level increases.
4. Clades within *Dendrobium* that are strongly supported do not always have clear morphological characters or combinations of characters by which they can be recognised. Splitting would almost inevitably create genera that even specialists would find hard to identify.

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5. Morphological and molecular phylograms can be widely incongruent e.g. in *Dendrocoryne* (Adams *et al.* 2006; Burke *et al.* 2008), with morphological trees resolving when molecular ones do not. Using molecular results alone in these circumstances is problematic.

6. Splitting would result in a degree of name changes for horticulturally important species that many orchid growers would find unacceptable. Many long used registered hybrid names would become confused and not compatible with future registrations. Name changes would also be inconvenient for ecologists, plant geographers, and other users.

If *Cadetia*, *Diplocaulobium* and *Flickingeria* are (re)included in *Dendrobium*, then such less widely accepted split-off genera as *Australorchis, Cannaeorchis, Cepalobaculum, Dockrillia, Durabaculum, Euphlebium, Grastidium, Sayeria, Tetrabaculum, Tropilis, Winika* and others can not be upheld. They too are nested within *Dendrobium s.l. Dockrillia*, for example, is nested within the *Dendrocoryne* clade, with species in at least three separate subclades (Burke *et al.* 2008) that would require three genera if splitting was adopted. Further, these subclades do not correlate at all well with the four or more major morphological subtypes occurring in Schlechter's section *Rhizobium*. Therefore we consider it preferable to reinclude *Dockrillia* in *Dendrobium*. The approach resulting in the following new combinations follows Option 1 of Burke *et al.* (2008), except for *Epigeneium*. It is the only genus in the Dendrobiinae that might be recognised next to a broadly circumscribed *Dendrobium*, since it has been found to be the sister group to all the other Dendrobiinae in all molecular analyses. Morphologically, however, *Epigeneium* is not more distinctive than former genera like *Cadetia* or *Flickingeria* that in our opinion should be included in *Dendrobium*. Including *Epigeneium* in *Dendrobium* would not add any obvious new character-states or combinations thereof to the genus. There are species of *Dendrobium* that are very similar to *Epigeneium*, both in vegetative as well as in floral characters, for example the Australian *D. carrii* Rupp & C.T.White. We do not know if these similarities are due to convergent evolution or because *D. carrii* has retained plesiomorphic character states, but it would be potentially confusing to include such similar plants in two different genera merely because they reside in sister groups. As another example, *D.* (*Epigeneium*) *fargesii* Finet and *D.* (*Diplocaulobium*) *cyclobulbon* Schltr. are very similar in habit. The flowers of *Epigeneium* are in no way unique, and could be called typical *Dendrobium* flowers if such a thing as a typical *Dendrobium* flower existed, compare for example *D.* (*Epigeneium*) *cymbidioides* (Blume) Lindl. with *D.* (*Dendrocoryne*) *finniganense* D.L.Jones or *D.* (*Epigeneium*) *nakaharae* Schltr. with *D.* (*Latouria*) *convolutum* Rolfe. If sister group status alone would be a sufficient criterion to recognise separate taxa, then, to give just one example, by analogy Apostasioideae should be considered to be a family in its own right, not just a subfamily of the Orchidaceae. Therefore, we prefer to reintegrate *Epigeneium* in *Dendrobium* as well, in which it used to be recognised as the section *Sarcopodium*, for example by Schlechter (1912).

A revised classification of *Dendrobium* at the subgenus and section level is urgently needed. It is fairly clear from the phylogenetic studies performed so far that Schlechter's (1912) widely used system is rather well supported at the section level, but hardly at all at the subgeneric level. For example, his subgenus *Athecebium* would unite species like *Dendrobium speciosum* Sm. and *D. lindleyi* Steud., which as we now know reside far apart in the two main clades, the Australasian and the Asian one respectively. There are also a number of complicated nomenclatural problems to be solved, depending on the rank and circumscription of the infrageneric groups. We intend to treat these matters, and the broader difficulties concerning *Dendrobium* taxonomy in separate publications.

Conclusions – New Combinations

Fortunately, most of the species of *Cadetia*, *Diplocaulobium*, etc., already have valid names under *Dendrobium*, so that only a limited number of new combinations are required. The following recombinations are for those species that do not presently have a valid name under *Dendrobium*.

(*Cadetia*)

Dendrobium collinsii* (Lavarack) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Cadetia collinsii* Lavarack, *Austrobaileya* 1: 381 (1981).

Distribution: Australia (Queensland).

***Dendrobium microphyton* L.O.Williams, *Bot. Mus. Leafl.* 5: 47 (1937).**

Cadetia microphyton (L.O.Williams) Christenson, *Lindleyana* 7: 89 (1992).

Cadetia siewhongii P.O'Byrne, *Malayan Orchid Rev.* 30: 73 (1996), *syn. nov.*

Distribution: Philippines, Sulawesi.

Note: We have seen a living specimen of *C. siewhongii* (Hortus botanicus Leiden cult. 970708) and compared this with the type material of *D. microphyton*. They are undoubtedly the same species.

Dendrobium obreniforme* Schuit. & P.B.Adams, *nom. nov.

Basionym: *Cadetia finisterrae* Schltr., *Repert. Spec. Nov. Regni Veg.* Beih. 1: 436 (1912).

Dendrobium finisterrae (Schltr.) J.J.Sm., *Bull. Jard. Bot. Buitenzorg*, sér. 2, 8: 18 (1912) (*nom. illeg.*).

Not *Dendrobium finisterrae* Schltr., *Repert. Spec. Nov. Regni Veg.* Beih. 1: 495 (1912).

Distribution: New Guinea.

Note: The specific epithet refers to the shape of the mid-lobe of the lip.

Dendrobium reconditum* Schuit. & P.B.Adams, *nom. nov.

Basionym: *Cadetia clausa* D.L.Jones & M.A.Clem., *Australian Orchid Res.* 5: 4 (2006).

Not *Dendrobium clausum* Schltr., *Repert. Spec. Nov. Regni Veg. Beih.* 1: 607 (1912).

Distribution: Australia (Moa Island).

Note: The specific epithet refers to the cleistogamous flowers (*reconditum*: 'concealed.')

[*Cadetia similis* Blume, *Rumphia* 4: 39 (1849).]

Dendrobium simile (Blume) J.J.Sm., *Nova Guinea* 8, 1: 53 (1909) (*nom. illeg.*).

Not *Dendrobium simile* Schltr., in K.Schum. & Lauterb., *Nachtr. Fl. Deutsch. Schutzgeb. Südsee* 175 (1905).

Not *Dendrobium simile* Schltr., *Repert. Spec. Nov. Regni Veg.* 3: 80 (1906) (*nom. illeg.*).

Distribution: New Guinea.

Note: Blume's description is insufficiently detailed. Unless type material is found, this species, which is related to *D. umbellatum* (Gaudich.) Rchb.f., will probably remain obscure. For that reason we refrain from proposing a new epithet under *Dendrobium* for this taxon.

Dendrobium vanuatuense* Schuit. & P.B.Adams, *nom. nov.

Basionym: *Cadetia quadrangularis* P.J.Cribb & B.A.Lewis, *Orchid Rev.* 97: 251 (1989).

Not *Dendrobium quadrangulare* Parish & Rchb.f., *Flora* 69: 553 (1886).

Distribution: Vanuatu.

Note: The specific epithet refers to the area of origin of this species.

(*Diplocaulobium*)

Dendrobium ancipitum* (P.O'Byrne & J.J.Verm.) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Diplocaulobium ancipitum* P.O'Byrne & J.J.Verm., *Malesian Orchid J.* 3: 44 (2009).

Distribution: Sulawesi.

Dendrobium anisobulbon* Schuit. & P.B.Adams, *nom. nov.

Basionym: *Dendrobium filiforme* J.J.Sm., *Icon. Bogor.* 2: 73 (1903) (*nom. illeg.*).

Diplocaulobium anisobulbon P.O'Byrne & J.J.Verm., *Malesian Orchid J.* 3: 46 (2009) (nom. superfl.).

Diplocaulobium filiforme Kraenzl., in Engl., *Pflanzenr.* IV. 50. II. B. 21: 341 (1910).

Not *Dendrobium filiforme* Wight, *Icon. Pl. Ind. Or.* 5: 5 (1852).

Distribution: Sulawesi.

Note: By article 58.1 of the International Code of Botanical Nomenclature (McNeill et al. 2006) the combination *Diplocaulobium filiforme*, based on the illegitimate name *Dendrobium filiforme* J.J.Sm., is legitimate if treated as a new name. This makes the new name *Diplocaulobium anisobulbon* proposed for *Diplocaulobium filiforme* superfluous, hence illegitimate. However, the epithet *anisobulbon* is still available in *Dendrobium*, therefore the combination

Dendrobium anisobulbon is legitimate if treated as a new name, as we did here.

Dendrobium begaudii* (Cavestro) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Diplocaulobium begaudii* Cavestro, *Orchidophile* 145: 9 (2001).

Distribution: New Caledonia.

Dendrobium crenatilobum* (P.O'Byrne & J.J.Verm.) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Diplocaulobium crenatilobum* P.O'Byrne & J.J.Verm., *Malesian Orchid J.* 3: 49 (2009).

Distribution: Sulawesi.

Dendrobium erythrosema* (P.O'Byrne & J.J.Verm.) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Diplocaulobium erythrosema* P.O'Byrne & J.J.Verm., *Malesian Orchid J.* 3: 51 (2009).

Distribution: Sulawesi.

Dendrobium magnilabre* (P.J.Cribb & B.A.Lewis) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Diplocaulobium magnilabre* P.J.Cribb & B.A.Lewis, *Lindleyana* 6: 31 (1991).

Distribution: Solomon Islands.

Dendrobium pangunaense* (Ormerod) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Diplocaulobium pangunaense* Ormerod, *Orchadian* 16: 275 (2009).

Distribution: Solomon Islands (Bougainville).

Dendrobium pohnpeiense* Schuit. & P.B.Adams, *nom. nov.

Basionym: *Diplocaulobium carolinense* A.D.Hawkes, *Pacific Sci.* 6: 7 (1952).

Not *Dendrobium carolinense* Schltr., *Bot. Jahrb. Syst.* 56: 472 (1921).

Distribution: Carolines (Pohnpei).

Note: The specific epithet refers to the island of origin of this species.

Dendrobium solomonense* (Carr) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Diplocaulobium solomonense* Carr, *Bull. Misc. Inform. Kew* 380 (1934).

Distribution: Solomon Islands.

Dendrobium stenophytoides* (P.O'Byrne & J.J.Verm.) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Diplocaulobium stenophytoides* P.O'Byrne & J.J.Verm., *Malesian Orchid J.* 3: 60 (2009).

Distribution: Sulawesi.

Dendrobium subintegrum* (P.J.Cribb & B.A.Lewis) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Diplocaulobium subintegrum* P.J.Cribb & B.A.Lewis, *Lindleyana* 6: 33 (1991).

Distribution: Solomon Is.

Dendrobium textile* J.J.Sm. var. *haematostictum* (P.O'Byrne & J.J.Verm.) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Diplocaulobium textile* (J.J.Sm.) P.F.Hunt & Summerh. var. *haematostictum* P.O'Byrne & J.J.Verm., *Malesian Orchid J.* 3: 66 (2009).

Distribution: Sulawesi.

(*Epigeneium*)

Dendrobium acutilingue* Schuit. & P.B.Adams, *nom. nov.

Basionym: *Dendrobium acuminatum* Rolfe ex Ames, *Orchidaceae* 1: 86 (1905) (*nom. illeg.*).

Epigeneium acuminatum Summerh., *Kew Bull.* 260 (1957).

Katherinea acuminata A.D.Hawkes, *Lloydia* 19: 94 (1956).

Sarcopodium acuminatum Rolfe, *Orchid Rev.* 18: 239 (1910).

Not *Dendrobium acuminatum* Kunth, *Nov. Gen. Sp* 1: 357 (1816).

Distribution: Philippines.

Note: The specific epithet refers to the pointed mid-lobe of the lip (*acutilingue*: 'sharp-tongued.')

Dendrobium arjunoense* (J.J.Wood & J.B.Comber) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Epigeneium arjunoense* J.J.Wood & J.B.Comber, *Orchid Rev.* 104: 286 (1996).

Distribution: Java.

Dendrobium brunneum* Schuit. & P.B.Adams, *nom. nov.

Basionym: *Epigeneium chapaense* Gagnep., *Bull. Mus. Hist. Nat.* (Paris), sér. 2, 4: 596 (1932).

Sarcopodium chapaense (Gagnep.) Tang & F.T.Wang, *Acta Phytotax. Sin.* 1: 83 (1951).

Not *Dendrobium chapaense* Aver., *Rheedea* 16: 3 (2006).

Distribution: Vietnam, ?China.

Note: The specific epithet refers to the brown flowers.

Dendrobium forrestii (Ormerod) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Epigeneium forrestii* Ormerod, *Taiwania* 52: 307 (2007).

Distribution: China (Yunnan).

Dendrobium gaoligongense (Hong Yu & S.G.Zhang) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Epigeneium gaoligongense* Hong Yu & S.G.Zhang, *Novon* 15: 495 (2005).

Distribution: China (Yunnan).

Dendrobium mariae Schuit. & P.B.Adams, *nom. nov.*

Basionym: *Epigeneium clemensiae* Gagnep., *Bull. Mus. Hist. Nat.* (Paris) sér. 2, 4: 595 (1932).

Epigeneium delacourii Gagnep., *Bull. Mus. Hist. Nat.* (Paris), sér. 2, 4: 595 (1932).

Not *Dendrobium clemensiae* Ames, *Philipp. J. Sci.*, C, 7: 16 (1912).

Not *Dendrobium delacourii* Guillaumin, *Bull. Mus. Hist. Nat.* (Paris) 30: 522 (1924).

Distribution: China, Laos, Vietnam.

Note: The specific epithet honours the intrepid Mary Strong Clemens, discoverer of this species.

Dendrobium mimicum (Ormerod) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Epigeneium mimicum* Ormerod, *Taiwania* 48, 3: 139 (2003).

Distribution: Thailand, China (Guangxi).

Dendrobium treutleri (Hook.f.) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Coelogyne treutleri* Hook.f., *Fl. Brit. Ind.* 5: 837 (1890).

Epigeneium treutleri (Hook.f.) Ormerod, *Oasis* 1: 3 (2000).

Pleione treutleri (Hook.f.) Kuntze, *Rev. Gen. Pl.*: 680 (1891).

Epigeneium yunnanense Tang & Z.H.Tsi, *Acta Phytotax. Sin.* 22: 484 (1984).

Distribution: India (Sikkim), Bhutan, Burma, China (Yunnan).

Dendrobium tsangianum (Ormerod) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Epigeneium tsangianum* Ormerod, *Taiwania* 49, 2: 97 (2004).

Distribution: China (Guangxi).

(*Euphlebium*)

Dendrobium decoratum (M.A.Clem. & Cootes) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Euphlebium decoratum* M.A.Clem & Cootes, *Orchideenj.* 16: 26 (2009).

Distribution: Philippines.

Dendrobium rhodochilum (Ferreras & Cootes) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Euphlebium rhodochilum* Ferreras & Cootes, *Orchideenj.* 17: 54 (2010).

Distribution: Philippines.

(*Flickingeria*)

Dendrobium abhaycharanii (Phukan & A.A.Mao) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Flickingeria abhaycharanii* Phukan & A.A.Mao, *Orchid Rev.* 113: 22 (2005).

Distribution: India (Assam).

Dendrobium albopurpureum (Seidenf.) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Flickingeria albopurpurea* Seidenf., *Dansk Bot. Ark.* 34, 1: 48 (1980).

Distribution: Thailand, China (Yunnan), Laos, Vietnam.

Dendrobium blaoense Schuit. & P.B.Adams, *nom. nov.*

Basionym: *Flickingeria vietnamensis* Seidenf., *Opera Bot.* 114: 205 (1992).

Not *Dendrobium vietnamense* Aver., *J. Orchideenfreund* 12: 3SS (2004).

Distribution: Vietnam.

Note: The specific epithet refers to the type locality.

Dendrobium calocephalum (Z.H.Tsi & S.C.Chen) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Flickingeria calocephala* Z.H.Tsi & S.C.Chen, *Acta Phytotax. Sin.* 33: 203 (1995).

Distribution: China (Yunnan).

Dendrobium chiengmaiense Schuit. & P.B.Adams, *nom. nov.*

Basionym: *Flickingeria parishii* Seidenf., *Dansk Bot. Ark.* 34, 1: 29 (1980).

Not *Dendrobium parishii* Rchb.f., *Bot. Zeitung* (Berlin) 21: 236 (1863).

Distribution: Burma, Thailand.

Note: The specific epithet refers to the area of origin of this species, the region around Chieng Mai in Thailand.

Dendrobium comatum (Blume) Lindl., *Gen. Sp. Orchid.* Pl.: 76 (1830).

Dendrobium comatum (Blume) Lindl. var. *papuanum* J.J.Sm., *Nova Guinea* B, 3: 551 (1911).

Dendrobium criniferum Lindl., *Edwards's Bot. Reg.*: Misc. (1844) 41.

Dendrobium scopa Lindl., *Edwards's Bot. Reg.* Misc. 55 (1842).

Dendrobium thysanochilum Schltr., in K.Schum. & Lauterb., *Nachtr. Fl. Deutsch. Schutzgeb. Südsee* 152 (1905).

Flickingeria clementsii D.L.Jones, *Orchadian* 14 (8: Scientific Suppl.) ix (2004), *syn. nov.*

Distribution: Taiwan, Peninsular Malaysia, Sumatra, Java, Borneo, Sulawesi, Moluccas, ?Lesser Sunda Islands, Philippines, New Guinea, Australia (Queensland), Solomon Islands, Vanuatu, New Caledonia, Fiji, Samoa.

Note: We do not see significant differences between Australian specimens of *D. comatum* (described as *F. clementsii*) and those found elsewhere.

Dendrobium compressibulbum Schuit. & P.B.Adams, *nom. nov.*

Basionym: *Flickingeria compressa* Seidenf., *Dansk Bot. Ark.* 34, 1: 31 (1980).

Not *Dendrobium compressum* Lindl., *Edwards's Bot. Reg.* Misc. 63 (1842).

Distribution: Thailand.

Note: The specific epithet refers to the laterally flattened pseudobulbs.

Dendrobium concolor (Z.H.Tsi & S.C.Chen) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Flickingeria concolor* Z.H.Tsi & S.C.Chen, *Acta Phytotax. Sin.* 33: 204 (1995).

Distribution: China (Yunnan).

Dendrobium hesperis (Seidenf.) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Flickingeria hesperis* Seidenf., *Nordic J. Bot.* 2: 16 (1982).

Distribution: India.

Dendrobium junctilobum (Fessel & Lueckel) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Flickingeria junctiloba* Fessel & Lueckel, *Orchidee* 49: 254 (1998).

Distribution: Philippines.

Dendrobium nazaretii (P.O'Byrne & J.J.Verm.) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Flickingeria nazaretii* P.O'Byrne & J.J.Verm., *Malayan Orchid Rev.* 37: 92 (2003).

Distribution: Sulawesi.

Dendrobium omissum Schuit. & P.B.Adams, *nom. nov.*

Flickingeria praetermissa W.Suarez & Cootes, *Philipp. Orchid Rev.* 15(2): 19 (2007).

Not *Dendrobium praetermissum* Seidenf., *Contrib. Orchid Fl. Thailand* XIII 34 (1997).

Distribution: Philippines.

Note: The specific epithet (*omissum*: 'disregarded') conveys the same meaning as that of the basionym *praetermissa*: 'overlooked.'

Dendrobium phuketense Schuit. & P.B.Adams, *nom. nov.*

Basionym: *Flickingeria insularis* Seidenf., *Dansk Bot. Ark.* 34, 1: 31 (1980).

Not *Dendrobium insulare* Steud., *Nomencl. Bot.*, ed. 2, 2: 489 (1841).

Distribution: Thailand.

Note: The specific epithet refers to the type locality.

Dendrobium shihfuanum (T.P.Lin & Kuo Huang) Schuit. & P.B.Adams, *comb. nov.*

Basionym: *Flickingeria shihfuana* T.P.Lin & Kuo Huang, *Taiwania* 50: 292 (2005).

Distribution: Taiwan.

Dendrobium tetralobatum* (P.O'Byrne & J.J.Verm.) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Flickingeria tetralobata* P.O'Byrne & J.J.Verm., *Malayan Orchid Rev.* 39: 80 (2005).

Distribution: Sulawesi.

Dendrobium tricristatum* Schuit. & P.B.Adams, *nom. nov.

Basionym: *Flickingeria tricarinata* Z.H.Tsi & S.C.Chen, *Acta Phytotax. Sin.* 33: 201 (1995).

Not *Dendrobium tricarinatum* Schuit. & de Vogel, *Malesian Orchid J.* 4: 104 (2009) (*nom. superfl.* = *D. humilicolle* Schltr., *Bot. Jahrb. Syst.* 58: 98 (1923).)

Distribution: China (Yunnan).

Note: The specific epithet refers to the three keels on the lip.

Dendrobium trifurcatum* (Carr) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Desmotrichum trifurcatum* Carr, *J. Malayan Branch Roy. Asiat. Soc.* 11: 85 (1933).

Ephemerantha trifurcata (Carr) P.F.Hunt & Summerh., *Taxon* 10: 106 (1961).

Flickingeria trifurcata (Carr) A.D.Hawkes, *Orchid Weekly* 2: 459 (1961).

Distribution: Sumatra.

Dendrobium tsii* Schuit. & P.B.Adams, *nom. nov.

Basionym: *Flickingeria bicolor* Z.H.Tsi & S.C.Chen, *Acta Phytotax. Sin.* 33: 204 (1995).

Not *Dendrobium bicolor* (Ruiz & Pav.) *Pers., Syn.* Pl. 2: 524 (1807).

Not *Dendrobium bicolor* Lindl., *Gen. Sp. Orchid.* Pl. 90 (1830) (*nom. illeg.*)

Distribution: China (Yunnan).

Note: The specific epithet honours Zhan Huo Tsi, co-describer of this species.

Dendrobium unibulbe* (Seidenf.) Schuit. & P.B.Adams, *comb. nov.

Basionym: *Flickingeria unibulbis* Seidenf., *Dansk Bot. Ark.* 34, 1: 54 (1980).

Distribution: Thailand, Vietnam.

Note: This is very similar to *D. bancanum* J.J.Sm., but appears to differ in the creeping, not erect rhizome.

(Grastidium)

Dendrobium chloranthum* Schuit. & P.B.Adams, *nom. nov.

Basionym: *Grastidium chlorinum* M.A.Clem. & Cootes, *Orchideenj.* 16: 24 (2009).

Not *Dendrobium chlorinum* Ridl., *Trans. Linn. Soc. London Bot.* 9: 172 (1916).

Distribution: Philippines.

Note: The specific epithet refers to the green flowers.

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New combinations and two new central Queensland taxa in the *Dendrobium tetragonum* (Orchidaceae:Epidendroideae) complex

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Introduction

The *Dendrobium tetragonum* A.Cunn. complex (Orchidaceae: sect. *Dendrocoryne*) has attracted a number of proposals for taxonomic revision following the initial description of several varieties (Leaney 1934; Gilbert 1937, 1942; Nicholls 1942). Clements and Jones (1990) re-interpreted var. *giganteum* Leaney (Leaney 1934) and named *D. capitisyork* M.A.Clem. & D.L. Jones and *D. cacatua* M.A.Clem. & D.L. Jones, as well as describing *D. melaleucaphilum* M.A.Clem. & D.L. Jones as a new member of the complex (Clements 1989; Clements and Jones 1990). They later proposed the genus *Tetrabaculum* (Clements and Jones 2002) to include all members of the *D. tetragonum* complex as separate species. Other authors have chosen to reject these proposals and continue to recognise the four entities at varietal rank (Dockrill 1992; Lavarack et *al.* 2000; Adams et *al.* 2006; Wood 2006). Molecular studies (Burke et *al.* 2008) and morphological analysis (Adams et *al.* 2006) do not provide evidence for either *Tetrabaculum* or the elevation of the varieties to specific rank. Previous morphological analysis (Adams et *al.* 2006) indicated that *D. tetragonum* has considerable variation which is not accounted for by recognising four taxa, and that more extensive sampling is required.

The term 'complex' or 'species complex' is used in the literature with different meanings and requires further definition. 'Species complex' is interpreted here as a group of variants that are closely related and identifiable as one species and not sufficiently and consistently distinctive in qualitative characters to be considered as separate species (Adams et *al.* 2006; Burke et *al.* 2008; Adams et *al.* 2007). This applies to *D. tetragonum* and other species in section *Dendrocoryne*, *D. speciosum* Sm. and *D. kingianum* Bidwell ex Lindl.

Clements and Jones (1990) stated that they examined hundreds of collections of *D. tetragonum* throughout its range, showing only four

Abstract

Two new taxa of *Dendrobium tetragonum*, *D. tetragonum* subspecies *cataractarum*, and subspecies *tetragonum* var. *serpentis*, are described from remote areas of central Queensland. A new classification of the *D. tetragonum* complex is presented on the basis of distribution, morphology and published molecular analyses, establishing northern, central and southern subspecies, with a total of six varieties. A neotype is assigned for *D. tetragonum* var. *giganteum* Leaney, the earliest described taxon of the complex in northern Australia.

Keywords: *Dendrocoryne*, classification, taxonomy, species complex, Australian orchids

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'distinct segregates' based on consistent floral features. Field exploration and discovery in remote parts of central Queensland by the author and associates between 1991 and 2009 have indicated that there are further variations in the *D. tetragonum* complex which warrant description and interpretation as part of the complex.

Two new taxa with geographical distributions separate from the other varieties are now described and discussed. The taxonomy of var. *giganteum* is revised, with assignment of a neotype for *D. tetragonum* var. *giganteum* Leaney.

Taxonomy

Dendrobium tetragonum subsp. *tetragonum* var. *serpentis* P.B.Adams var. nov.

Flores sub anthesi virides postea lutei, segmenta angusta delicata. Labellum conspicuum lobo mediano cordiformi, a latere viso concavo, apex recurvatus, callus demissus 3-costatus, pili et projecturae labelli absenti.

Flowers at opening green, later yellow, segments narrow delicate. Labellum conspicuous, midlobe heart shaped, concave when viewed from the side, apex recurved, callus low, 3-ridged. Hairs and projections of the labellum absent.

Type: *Queensland*. Leichhardt District: Blackdown Tableland, 30/6/2010, *P.B.Adams* 23 (holo: MEL; iso: BRI)

Plants epiphytic, forming clumps attached to the host by thin wiry branching roots; *pseudobulbs* (canes) few c. 40, variously directed, not radiating perpendicularly, tetragonal except at the base where fusiform and tapering, up to 24 cm long × 8.5–10.5 mm wide, with 2–7 narrow segments proximally, 1–1.5 mm diameter at the base, and 2–3 expanded segments distally, narrowing via short internodes at the apex, pale green, covered in thin silvery velum when young; *leaves* 1–4, sessile via a short sheathing base, 4.2–7.8 cm long × 2.0–2.8 cm wide, narrow to broadly ovate with acute apices, rigid and recurving, often at approximately a right angle to canes, green with gentle undulations of margins, only the median vein prominent; *racemes* 1–3 per cane, produced at or near the apex and very rarely from any other nodes; *flower buds* twisting almost 360° in the distal half; *flowers* 2–5 per raceme, arising in the angle of a scarious orange-brown bract c. 6 mm long × 1 mm wide, at about 90° to the rachis, porrect, 6.3–8.0 cm long × 2.4–3.5 cm wide, clustered on a short raceme, showy and widely expanded with dorsal and lateral sepals tending to reflex strongly, tepals opening pale green and becoming pale yellow before senescing, some plants with pale orange colouration on distal half of sepals, but without red-brown sepal colouration except for occasional fine lines on some margins (visible with 10× magnification); *peduncle* c. 1.0–1.3 cm long × 0.8–1.2 mm wide, linear, green-yellow surrounded by several brown bracts c. 8 mm long × 2–3 mm wide, with acuminate apices; *pedicel and ovary* c. 1.4–2.0 cm long × c. 1–2 mm wide, gently curved, pale yellow; *ovary* c. 7 mm long × 2 mm wide, linear, pale yellow with a few fine purple spots; *dorsal sepal* 25–43 mm long × 4.5–5 mm wide, erect, initially linear and angulating slightly at 1 or 2 points along the length, apices long-acuminate; *lateral sepals* 23–41 mm long × 4–6 mm wide, falcate, wide (dilated) at base then subulate, apices long-acuminate, often reflexing and angulating laterally and asymmetrically; *petals* 16–25 mm long × 1.0–1.2 mm wide at base, held at an angle of c. 45° to dorsal sepal and recurving along length, divergent, linear, narrowing to acuminate apices; *labellum* very prominent, 14.5–16 mm long × 7.5–9.5 mm wide, trilobed on short claw, narrow at base and broad anteriorly, lateral lobes incurved to form an open channel 4–5 mm wide forwards of the column and not enclosing it, width less than midlobe when flattened c. 7.5–9 mm; midlobe directed forwards at c. 45°, white-pale cream with purple barring and spots, very flat and broad, presentation width 8–10 mm, apex small, apiculate and held forward, recurving with age; *callus* with 3 ridges, fused at base, very low in profile, the central one most prominent, extending a short distance on to the midlobe; *mentum* c. 7 mm × 4 mm, curved, pale yellow with faint dull purple streaks; *column* c. 7 mm × 3 mm, curved, porrect, pale yellow-green with a prominent purple-brown patch centrally below stigmatic cavity, and purple spotted and a deeper yellow at the base; *anther* white, becoming yellow with age, enclosing pollinia; *stigma* concave, apical, wet, oval shaped; *capsule* green c. 22 mm × 12 mm (Figs. 1,2).

Distribution and habitat: Gorges and creeks of the northern part of the Blackdown Tableland, central Queensland, restricted, extent uncertain. Sheltered

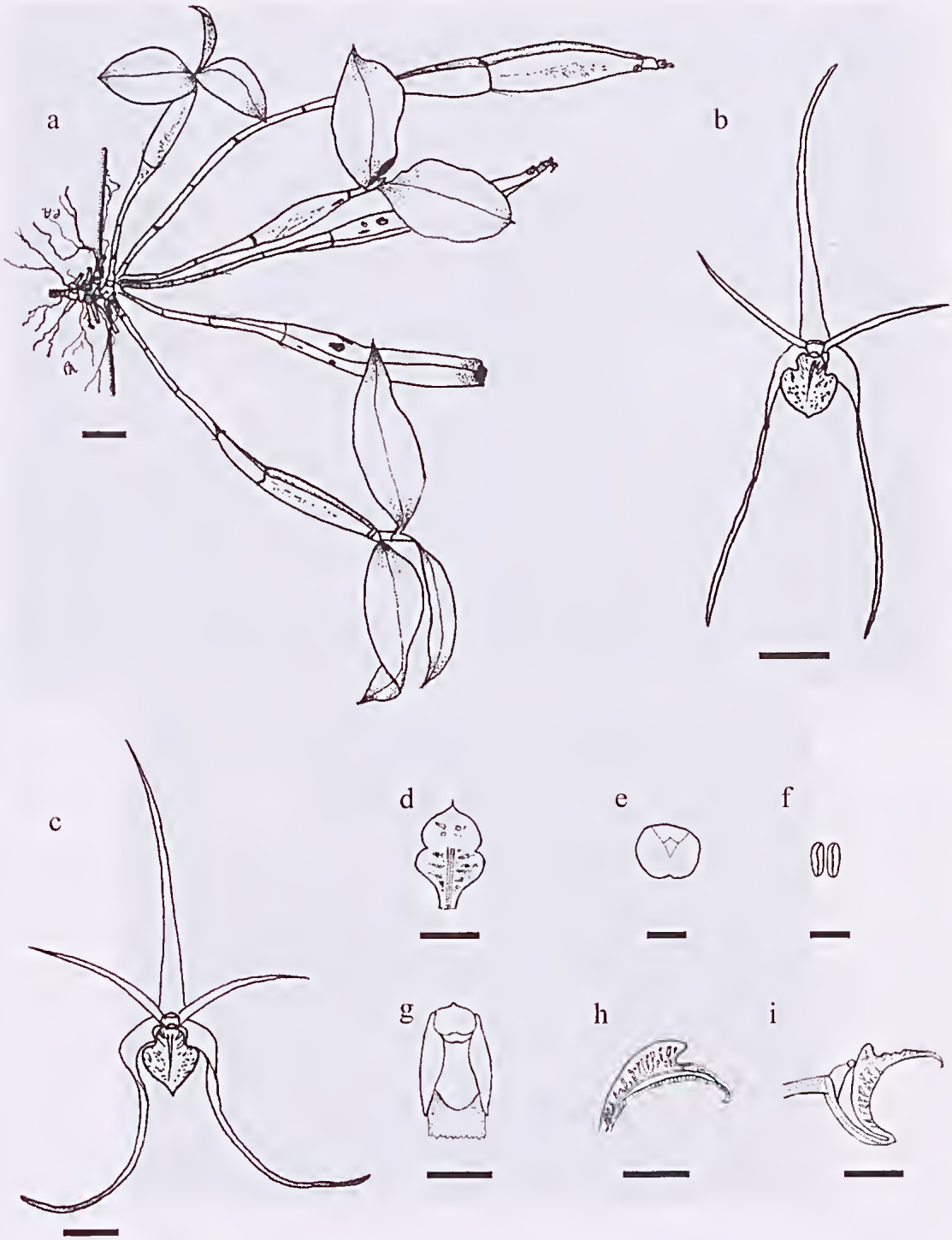

Figure 1. Habit and floral morphology of *D. tetragonum* subsp. *tetragonum* var. *serpentis*. **a**. plant, scale bar = 10 mm; **b**. flower from front, scale bar = 8 mm; **c**. flower variant, scale bar = 8 mm; **d**. labellum flattened, scale bar = 9 mm; **e**. anther, front view, scale bar = 0.75 mm; **f**. pollinia, scale = 1 mm; **g**. column from front, scale bar = 8 mm; **h**. labellum longitudinal section, scale bar = 7 mm; **i**. column and labellum from side, scale bar = 7 mm.

Figure 2. Photograph 2. *D. tetragonum* subsp. *tetragonum* var. *serpentis* **a.** flower ; **b.** another floral form; **c.** advanced buds showing prominent distal twisting

sandstone gorges and relictual rainforest with *Syzygium australe*, which is a favoured host.

Etymology: Named in reference to the Rainbow Serpent believed by the local indigenous people to inhabit Blackdown Tableland gorges.

Flowering period: August–September

Conservation status: *Dendrobium tetragonum* var. *serpentis* is conserved in national parks, in remote sites, but is very restricted and somewhat vulnerable to collection. It is protected by very dangerous and mostly inaccessible terrain, and has not been sufficiently surveyed to assign a coded conservation status.

Notes: Plants were studied using several collections made between 1991 and 2010. This variety has a distribution on the Blackdown Tableland, geographically separated by about 250 km from other described varieties. To the east, the nearest *D. tetragonum* is var. *melaleucaphilum* in the Berserker Range near Rockhampton. As in all varieties of the *D. tetragonum* complex, the differences from each other are quantitative. The small number of var. *serpentis* plants surveyed in a few remote populations show little variation between individuals in comparison with other varieties. There is a superficial resemblance to *D. tetragonum* var. *melaleucaphilum* but with the following significant differences.

The flower buds twist markedly in the distal half. There is a prominent and showy midlobe, flat and angled well forward away from the column and with an apex which protrudes as a visible point, reflexing only in some flowers with advanced age (early senescence). The flattened lateral lobes are not as wide as the presentation width of the midlobe (they are approximately equal in width in most specimens of var. *melaleucaphilum*). The flowers of var. *serpentis* are more elongate, with segment dimensions usually smaller than in var. *melaleucaphilum*, and there is a distinct colour change from green to pale yellow with age, and less variation between plants. The plants are small to moderate in size, consisting of up to 40 canes compared with var. *melaleucaphilum* with up to 100 canes (Clements and Jones 1990). Canes are not perpendicular and radiating out from the host as stated for var. *melaleucaphilum*, rather they are arranged in various directions including upwards and outwards (Fig.1)

Variety *serpentis* has no hairs or projections visible on the labellum at magnifications × 20. Most populations of var. *melaleucaphilum* examined have pilose projections over the midlobe and some areas of the callus, visible at magnification × 10.

Dendrobium tetragonum subsp. *cataractarum* P.B.Adams, S.D.Lawson and G.A. Paterson subsp. nov.

Flores virido-luteis, sepala margine purpureu-brunnea. Segmenta prope basin crassiuscula, relative lata distaliter. Labellum grandum, lobo mediano lato, prominentio, late ovato, a latere viso leniter concavo, apex acutus recurvatus, callus prominens 3-costatus, pili et projecturae labelli absenti.

Flowers yellow-green, sepals at the margin purple-brown. Segments near the base thickish, and relatively broad in distal half. Labellum large, with midlobe wide, very prominent, broadly ovate, when viewed from the side slightly concave, apex acute, recurved, callus prominent 3-ridged, hairs and projections of the labellum absent.

Type: Queensland. Port Curtis and South Kennedy districts; Connors Range, 1/8/1993. *P.B. Adams & S.D. Lawson 25* (holo: MEL; iso: BRI).

Plants epiphytic, forming clumps attached to hosts by thin wiry branching roots; *pseudobulbs* (canes) few to c. 15, variously directed, pale green, covered in silvery velum when young; fusiform at the base, tapering to tetragonal segments, up to 33 cm long × 7.0–12.5 mm wide; with 2–9 narrow segments proximally, 1–1.5 mm diameter at the base, and 2–3 expanded segments distally, narrowing via short internodes at the apex; *leaves* 1–3, sessile via a short sheathing base, 4.8–11.5 cm long × 1.8–3.5 cm wide, narrow to broadly ovate with acute apices, rigid, often at about a right angle to canes, green with undulations of margins, only the median vein prominent; *racemes* 1–3 per cane, produced at or near the apex, and rarely from any other nodes; *flower buds* slightly twisted towards the apex; *flowers* 1–6 per raceme, usually 2–4, arising in the angle of a scarious brown bract 7 mm long × 1 mm wide, at about 90° to the rachis, porrect, 6.3 – 8.9 cm long × 3.2 – 4.5 cm wide, clustered on a short raceme, showy, widely expanded with dorsal and lateral sepals of heavy substance and not reflexing, pale green to yellow with

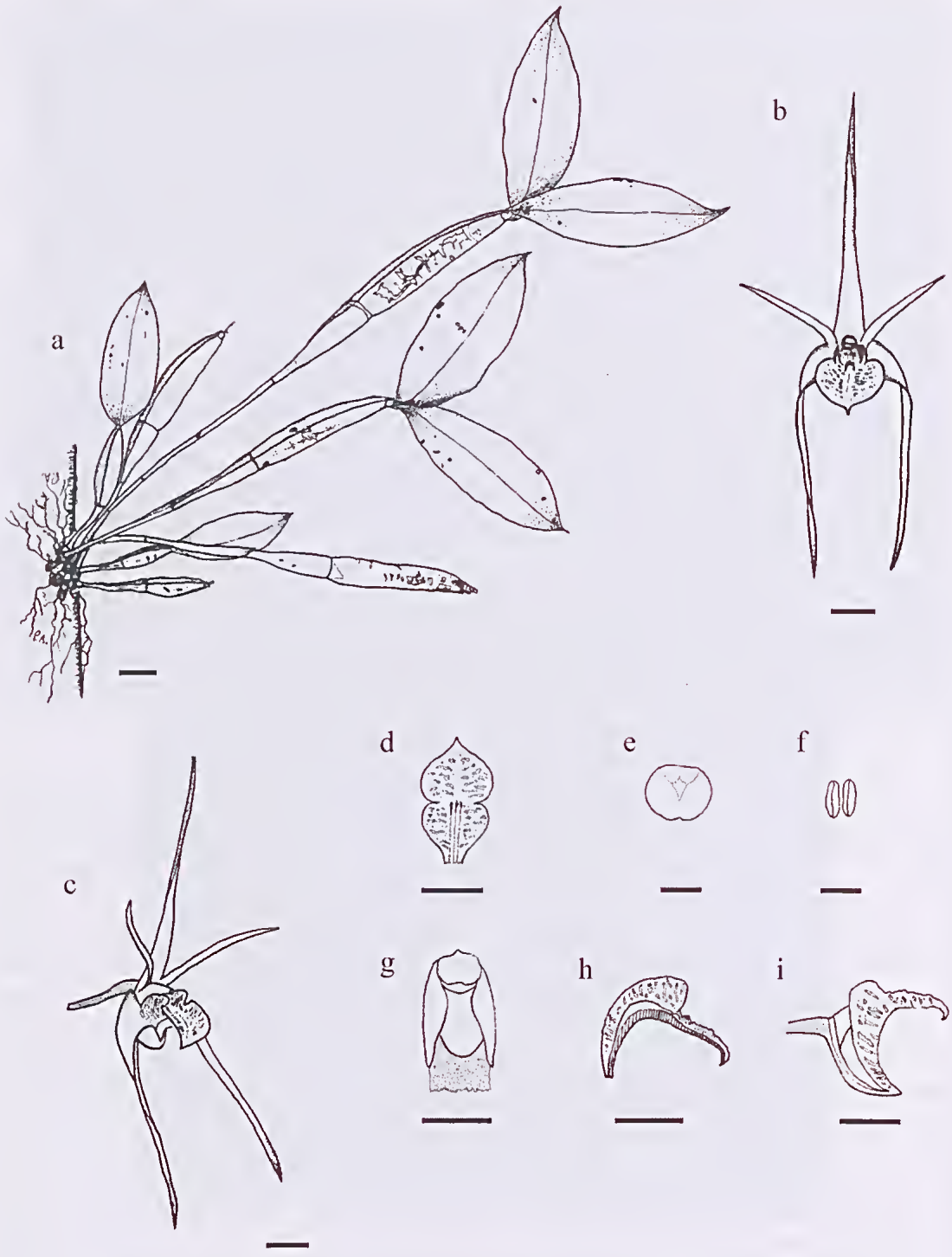

Figure 3. Habit and floral morphology of *D. tetragonum* subsp. *cataractarum*. **a.** plant scale, bar = 10 mm; **b.** flower from front, scale bar = 6.5mm; **c.** flower oblique view, scale bar = 6.5 mm; **d.** labellum flattened, scale bar = 10 mm; **e.** anther front view, scale bar = 0.75 mm; **f.** pollinia, scale bar = 1 mm; **g.** column from front, scale bar = 8 mm; **h.** labellum, longitudinal section, scale bar = 7 mm; **i.** column and labellum from side, scale bar = 7 mm.

prominent purple-brown on margins and distal areas; *labellum* very large and widely spreading, pale cream with red-purple spots and barring usually more intense on lateral lobes; *peduncle* c. 0.7–2.1 cm long × 0.8–1.2 mm wide, linear, green-yellow with several brown bracts c. 9 mm long × 2–3 mm wide, with acuminate apices; *pedicel and ovary* c. 1.2–2.3 cm long × 1 mm wide, curved, pale yellow-green; *ovary* c. 8 mm long × 2 mm wide, linear, yellow-green with a few fine purple-brown spots; *dorsal sepal* 40–63 mm long × 4.0–6.0 mm wide, erect, twisting once or nil, not angulating along the length, apices acuminate; *lateral sepals* 36–58 mm long × 4.0–7.5 mm wide, symmetrical, falcate, wide (dilated) at base then subulate, apices long-acuminate, usually twisting once and not angulated; *petals* 18–35 mm long × 1.2–1.7 mm wide, divergent, held at angles 45–80° to the dorsal sepal, not usually recurving, linear, narrowing to acuminate apices; labellum 13–19 mm long × 8.0–11 mm wide, trilobed on a short claw, narrow at base and very broad anteriorly, lateral lobes gently incurved to form a channel 4–6 mm wide, partially enclosing the column, width less than midlobe when flattened, c. 9.0–10 mm; *midlobe* angled forwards, flat, presentation width 9.5–12 mm, apex small, apiculate and slightly recurved; *callus* with 3 prominent ridges fused at base, extending a short distance onto midlobe, white-pale cream with fine purple-brown spots and bars; *mentum* c. 8 mm × 4 mm, curved, pale yellow; *column* c. 7 mm × 3 mm, curved, porrect, pale yellow; *anther* white-pale yellow, enclosing pollinia; *stigma* concave, apical, wet, oval shaped; *capsule* green *c.* 25 mm × 14 mm (Figs. 3,4).

Distribution and habitat: Restricted to Connors Range, central Queensland and very localised. Occurs along rainforest creeks, found in the canopy, on trunks and at bases of various small rainforest trees including *Austromyrtus*, *Ficus*, *Syzygium*, *Planchonella*, and *Euroschinus*.

Etymology: Named with reference to its occurrence, restricted to creeks with waterfalls.

Flowering period: August–September

Conservation status: 2V. Vulnerable due to extreme localization in very small populations. Plants occur in remote sites in mostly inaccessible terrain.

Notes: Plants were studied using several collections made between 1993 and 2010. *Dendrobium tetragonum* subsp. *cataractarum* is found at a few very remote sites along creeks in the Connors Range between Marlborough and Carmila, at elevations of 30–400 m. The full extent of distribution and variation is approximately determined, as many parts of the area are inaccessible. Populations are small, and restricted to places where there is semi-permanent water and sufficient humidity. There is a wide range of small and larger rainforest tree hosts with plants growing at various levels, often low down and on their bases. There is no geographical overlap with other described varieties.

Compared to var. *serpentis*, the dimensions of the labellum, flower width, sepal length and width, and petal width tend to be greater, contributing to a more robust flower. The sepals are wide distally and usually do not reflex in the manner of var. *serpentis*. Most flowers have prominent brown-purple markings on the sepal margins and distal third.

This taxon differs from var. *melaleucaphilum* in having a very showy, wide and flat labellum that reflexes at the apex only to a small extent. The labellum only partially encloses the column, obscuring only a part of it in lateral view. Unlike var. *melaleucaphilum*, the flattened lateral lobes are not as wide as the flattened width of the midlobe. In subsp. *cataractarum* there are no hairs or projections on the labellum at magnification × 10. Like var. *serpentis*, the relatively small size of the plants and radiating habit of the pseudobulbs in various directions is likely to be the result of marginal habitat quality.

Dendrobium tetragonum A.Cunn. subsp. *giganteum* (Leaney) P.B.Adams stat. nov.

Basionym: *Dendrobium tetragonum* A.Cunn. var. *giganteum* Leaney, *Orchidologia Zeylanica* 1: 73 (1934). ***Neotype*** (here chosen): Queensland. Cook District: South of Atherton, 10/5/2010, *P.B.Adams* 27 (holo: MEL; iso: BRI).

Dendrobium tetragonum A.Cunn. var. *giganteum* P.A. Gilbert, *Australian Orchid Review* 7:36 (1942) (nom. illeg.). *Dendrobium capitisyork* M.A.Clem. & D.L.Jones, *Australian Orchid Research* 1:49 (1989), *syn. nov.*; *Tetrabaculum capitisyork* (M.A.Clem. & D.L.Jones) M.A.Clem. & D.L.Jones, *Orchadian* 13:485-497 (2002), *syn. nov.*

Figure 4. Photograph 1. *D. tetragonum* subspecies *cataractarum*. **a.** flower; **b.** another floral form; **c.** advanced buds showing slight distal twisting.

Brief neotype diagnosis:

Plants epiphytic; *pseudobulbs* (canes) tetragonal, except basally where fusiform and wiry; *racemes* with 1-4 stellate, large flowers (5.0-13.2 cm long × 2.4-7.1 cm wide), variously coloured yellow-green with few darker markings, or with prominent red-purple-brown spots and blotches, or with wide areas of brown and red-purple on tepals; *labellum* white with prominent red-purple markings and three callus ridges; *lateral lobes* forming a narrow to more commonly broad tunnel, narrow to very wide (0.6-1.85 cm when flattened); *midlobe* relatively small (0.45-0.75 cm) when flattened, and long, acuminate and reflexed at apex, with from inconspicuous to prominent filiform hairs.

Classification of the *Dendrobium tetragonum* A.Cunn. complex

The complex is classified as set out below, on the basis of detailed distribution studies, morphological characteristics of the six taxa and molecular analyses. Three subspecies are established, with northern, central and southern distributions.

Dendrobium tetragonum A.Cunn. subsp. *tetragonum* var. *tetragonum*

Basionym: *Dendrobium tetragonum* A.Cunn. in *Edwards Botanical Register* 25, misc. 33 (1839); *Callista tetragona* (Cunn.) Küntze, *Revis Gen Pl* 2: 655 (1891); *Dendrocoryne tetragona* (Cunn.) Brieg., Schlechter, *Die Orchideen* 3: 716 (1981) (nom. invalid.); *Tropilis tetragona* (Cunn.) Butzin, *Willdenowia* 12: 250 (1982); *Tropilis tetragona* (Cunn.) Rauschert, *Feddes Repert* 94: 471 (1983) (nom. illeg.); *Dendrobium tetragonum* Cunn. var. *hayesianum* P.A.Gilbert, P.A.Gilbert, *Australian Orchid Review* 2: 20 (1937); *Tetrabaculum tetragonum* (A. Cunn) M.A.Clem. & D.L.Jones, M.A. Clements & D.L. Jones, *Orchadian* 13: 485-497 (2002).

Dendrobium tetragonum A.Cunn. subsp. *tetragonum* var. *melaleucophilum* M.A.Clem. & D.L.Jones

Basionym: *Dendrobium melaleucaphilum* M.A.Clem. & D.L.Jones, *Australian Orchid Research* 1: 57 (1989); *Tetrabaculum melaleucaphilum* (M.A.Clem. & D.L.Jones), M.A. Clements & D.L. Jones, *Orchadian* 13: 485-497 (2002).

Dendrobium tetragonum A.Cunn. subsp. *tetragonum* var. *serpentis* P.B.Adams

Dendrobium tetragonum A.Cunn. subsp. *cataractarum* P.B.Adams, S.D.Lawson & G.A.Paterson

Dendrobium tetragonum A.Cunn. subsp. *giganteum* (Leaney) P.B.Adams var. *giganteum*

Basionym: *Dendrobium tetragonum* A.Cunn. var. *giganteum* Leaney, *Orchidologica Zeylanica* 1: 73 (1934); *Dendrobium tetragonum* A.Cunn. var. *giganteum* P.A. Gilbert, *Australian Orchid Review* 7: 36 (1942) (nom. illeg.); *Dendrobium tetragonum* A. Cunn. var. *tomentosum*, *Australian Orchid Review* 7: 40 (1942); *Dendrobium capitisyork* M.A.Clem. & D.L.Jones, *Australian Orchid Research* 1: 49 (1989); *Tetrabaculum capitisyork* (M.A.Clem. & D.L.Jones) M.A.Clem. & D.L.Jones, *Orchadian* 13: 485-497 (2002).

Key to subspecies of *Dendrabium tetraganum*

1 Midlobe of labellum much narrower than the lateral lobes, and usually sparsely-densely tomentose. Plants occurring from Carmila to Iron Range, Queensland ..... **subspecies *giganteum***

1: Midlobe of labellum approximately the same width or greater than the lateral lobes, and not conspicuously tomentose. Plants occurring from Nowra, New South Wales, to just south of Carmila, Queensland **2**

2 Flowers yellow-green usually with red-purple-brown on sepal margins; sepals robust, thickened at base; labellum pale cream with red-purple markings; midlobe very large, 9-12 mm wide, flat, angled forwards, not recurving at apex until flowers age. Plants occurring spasmodically between Marlborough and North Clairview, Queensland ..... **subspecies *cataractarum***

2: Flowers yellow-green-pale bronze with red-purple markings, either star-like with pronounced red-purple sepal margins, or elongated with sepals tending to twist and reflex; labellum white to cream with red-purple markings; midlobe usually less than 9 mm wide, and strongly recurving at apex. Plants occurring south of Clairview, Queensland ..... **subspecies *tetraganum***

***Dendrobium tetragonum* A.Cunn. subsp. *giganteum* (Leaney) P.B.Adams var. *cacatua* M.A.Clem. & D.L.Jones**

Basionym: *Dendrobium cacatua* M.A.Clem. & D.L.Jones, *Australian Orchid Research* 1: 48 (1989); *Tetrabaculum cacatua* (M.A.Clem. & D.L.Jones) M.A.Clem. & D.L.Jones, *Orchadian* 13: 485-497 (2002).

Discussion

The *Dendrobium tetragonum* complex has been interpreted as a group of closely related varieties that do not warrant specific status (Dockrill 1992; Lavarack *et al.* 2000; Adams *et al* 2006; Burke *et al.* 2008). Variation is on the basis of size of parts and colour patterns. Further, internal transcribed spacer of nuclear DNA (ITS-DNA) studies do not provide any contributing evidence (Burke *et al.* 2008) for reclassification of the complex as a separate genus *Tetrabaculum* as proposed by Clements and Jones (2002). The DNA studies suggest a molecular similarity between the two northern varieties, var. *giganteum* and var. *cacatua*, which are morphologically distinct (see key), except for intermediates where the two taxa overlap at some locations between 700 and 850 m of altitude, e.g. in the Crediton area. Similarly var. *tetragonum* and var. *melaleucaphilum* are also distinctive except where the two co-exist and intermediate forms are seen (Adams *et al.* 2006), e.g. in the Coffs Harbour area. This is contrary to the notes of Clements and Jones (1990) that both occasionally grow together and hybrids are unknown, and that the four varieties are biologically and geographically distinct.

Two options were considered for assigning rank at infraspecific level. The first and simplest was to continue use of the taxon variety for all previously described taxa and for the two new variants. The second option was to use recently available molecular data and morphology, which lead to a more complex two ranked system of subspecies and varieties. The latter option was chosen, as it provides more information about relationships, without a change of established varietal names. The nomenclature may be abbreviated, except for subspecies *cataractarum*, to the simple use of varieties, old and new, providing ongoing stability. Distribution, morphological characters and molecular evidence support the establishment of three subspecies. Principal co-ordinate analysis (Adams *et al.* 2006) and ITS-DNA results (Burke *et al.* 2008) clearly indicate a northern lineage, subspecies *giganteum*, consisting of var. *giganteum* and var. *cacatua*, and a southern lineage, subspecies *tetragonum*, with three varieties. Midlobe labellar features separate the northern subspecies *giganteum* from the other

Key to varieties of *Dendrobium tetragonum* subspecies *giganteum*

1 Flowers with long filamentous, pale green segments, occasionally with a few red-purple fine markings; labellum white, usually with no markings; lateral lobes larger than midlobe, which ends in a short apiculum. Plants usually above 750m altitude ..... **var. *cacatua***

1: Flowers usually strongly marked with red-purple-brown, occasionally yellow or green with very few, darker markings; labellum white with red-purple markings, lateral lobes usually huge compared with midlobe, which ends in a long apiculum. Plants usually below 750m altitude ..... **var. *giganteum***

Key to varieties of *Dendrobium tetragonum* subspecies *tetragonum*

1 Flowers opening green, later turning yellow, tepals with few or no red-purple markings; segments filamentous; midlobe prominent, cordiform, white-pale cream with red-purple markings, and recurving with age. Flower buds markedly twisted in the distal half. Plants of Blackdown Tableland, Queensland ..... **var. *serpentis***

1: Flowers and distribution not as above **2**

2 Flowers yellow-light green-light bronze, usually with reddish purple markings on sepals, not star-like, usually > 7.5 cm in vertical height; labellum cream-pale yellow with red- purple markings, broadly dilated and strongly recurving soon after opening ..... **var. *melaleucophilum***

2: Flowers yellow-green-light bronze, usually with very deep red-brown sepal markings, starlike, usually < 7.5 cm in vertical height; labellum white with red-purple markings; midlobe not broadly dilated, recurving soon after opening ..... **var. *tetragonum***

subspecies. The central subspecies *cataractarum* has robust floral features and an outstanding midlobe, the largest in the complex. The three southern varieties share similar labellar characteristics and differ mainly in flower size, colour and floral presentation, with significant overlap of characteristics in some parts of their ranges. A key separates the subspecies, but keys to the varieties require several characters and are not always successful, reflecting the interpretation that they should not be considered as separate species.

Descriptions at varietal level in a species complex such as *D. tetragonum* are difficult, with the possibility that examination of further specimens from the respective geographical ranges for these varieties may result in different quantitative ranges for characters. The sum total of the features described favours an interpretation of subgroups at infra-specific rank. This is consistent with the history of initial descriptions for *D. tetragonum* and provides a measure of nomenclatural stability. Horticulturalists and orchid growers may choose to continue the use of existing varietal names without reference to subspecies.

Unlike the other described varieties, subsp. *cataractarum* and var. *serpentis* have separate geographical ranges as far as can be determined. Each is fairly uniform in morphology, reflecting a relatively small distribution, and are not very variable at each site.

Variety *serpentis* is placed in the southern group (i.e. in subsp. *tetragonum*) on the basis of its distribution, affinities to var. *melaleucaphilum*, and DNA sequence which is almost identical with the other two other southern varieties (Burke unpublished). The morphological analysis of var. *serpentis* provides strong evidence for a taxon of varietal status with the same degree of subtle quantitative differences in characters as seen when comparing the other four varieties described. These are much more variable, as expected from their much greater distribution and wider variety of habitats. *Dendrobium tetragonum* subsp. *cataractarum* occupies a separate central distribution with no overlap with other varieties.

The north Queensland taxon *D. tetragonum* var. *giganteum* was originally described briefly by Leaney (1934) without a type specimen, and before the current requirements for describing new taxa. The taxonomy is historically confused. Leaney's description states "*D. tetragonum* var. *giganteum*. This variety comes from the Northern part of Australia and has large flowers of much more substance which are almost honey-coloured. Petals and sepals twisted". Gilbert (1937) then also described var. *giganteum* without a type, and later added a Latin validation (1942). He did not refer to Leaney. Dockrill, in Harrison (1998), noted that one of the plants used by Gilbert was supplied by Dockrill himself and was definitely the same taxon as the other material used by Gilbert in his description. The illustration of Nicholls (1942), which he described as var. *tomentosum*, is clearly var. *giganteum*. Clements and Jones (1990) synonymized var. *giganteum* Leaney under their *D. cacatua* and considered var. *giganteum* P.A.Gilbert (which is a later homonym) to be a mixed entity, partly (as to the material supplied by Dockrill) referable to *D. cacatua* and partly to *D. capitisyork*. However, plants with the morphology of var. *cacatua* were not known to Dockrill in the 1930s and 40s, and were not in cultivation. I regard Leaney's original description as referring to var. *giganteum* as here interpreted and typified, of which *D. capitisyork* is a synonym, and do not agree with the interpretation of the taxon as being a synonym of *D. cacatua*, which was evidently based on a questionable interpretation of the nonspecific term "honey-coloured". Honey ranges in colour from light straw to almost black, with brown the most usual connotation, this being the colour of some darker var. *giganteum* flowers, but not seen in var. *cacatua*. Leaney's description is supported by recent discoveries of lowland plants with pale yellow tepals and very few purple markings, and with other features typical of var. *giganteum*. Therefore I have recognized Leaney's taxon name *giganteum* at the rank of subspecies, and assigned a neotype, with *D. cacatua* classified as a variety of *D. tetragonum* subsp. *giganteum*.

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A new hierarchy conserving nomenclature for the *Dendrobium speciosum* Sm. complex (Orchidaceae: Epidendroideae)

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Abstract

A new hierarchy with two sub species is presented for the *Dendrobium speciosum* Sm. complex, considering previously published distributional, morphological, principal coordinate and ITS-DNA analyses. There are seven varieties in the southern subspecies *speciosum*, and two in the northern subspecies *pedunculatum*.

Keywords: Taxonomy, classification, species complex, *Dendrocoryne*

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Introduction

The taxonomic history of the *Dendrobium speciosum* (Orchidaceae sect. *Dendrocoryne*) complex has been reviewed (Adams *et al.* 2006a), and three new taxa described and analysed numerically (Adams *et al.* 2006ab). On the basis of these studies and a biological review (Adams 1991) nine varieties have been established, including the description of the type by Smith (1804).

Considering published results, primarily morphology and principal co-ordinate analysis (Adams *et al.* 2006 abc), and the internal transcribed spacer of nuclear DNA (ITS-DNA) (Burke *et al.* 2008), we recognise a northern subspecies *pedunculatum*, and a southern subspecies *speciosum* as indicated in the following classification. A new hierarchy is presented, with accompanying major characteristics for typical and commonly occurring forms, and distributions for each taxon. More detailed descriptions and distribution maps are provided in Adams *et al.* (2006 abc), and full synonomy and information concerning types is listed in Clements (1989).

Dendrobium speciosum Sm. subsp. *speciosum*

Dendrobium speciosum Sm. var. *speciosum*, *Exotic Botany* 1:17, t.10 (1804)

Syn. *Thelychiton speciosus* (Sm.) M.A.Clem. & D.L.Jones, *Orchadian* **13**, 492 (2002) in part; *Thelychiton epiphyticus* D.L.Jones & M.A.Clem, *Australian Orchid Research* **5**, 39 (2006) in part.

Large robust plants, mainly lithophytic, occasionally epiphytic in rainforest habitat e.g. Kangaroo Valley, New South Wales; occasional plants with aerial roots, pseudobulbs to 50 cm long, wide at the base and tapering towards apex; racemes 15–60 cm long, 18–115 flowered; flowers relatively large, vertical height 4.2–8.0 cm, horizontal width 4.3–7.8 cm, well spaced, pure white to yellow.

Flowering: August to October.

Distribution: Genoa (eastern Victoria) north to Bulahdelah and Barrington Tops, New South Wales, and inland to Munghorn Gap, New South Wales. Intergrades with var. *hillii* north of the Hunter River, New South Wales.

D. speciosum var. *hillii* Masters, *Gardeners Chronicle* (new series) p. 112, f. 18. (1877).

Syn. *Thelychiton tarberi* (M.A.Clem. & D.L.Jones) M.A.Clem. & D.L.Jones, *Orchadian* **13**, 492 (2002).

Typical plants large, medium to tall epiphytes or lithophytes, forming very large clumps in dense rainforest; often with well developed aerial roots; pseudobulbs erect to 75 cm long, virtually non-tapering; large leaves up to 30 cm long; racemes short to long (26–70 cm), 45–240 flowered; flowers mainly small, occasionally medium sized, vertical height 3.4–5.2 cm, horizontal width 2.9–5.3 cm, white to cream or occasionally pale yellow flowers, from well spaced on racemes to densely packed in crowded 'foxtails' with the most flowers per raceme in the species.

Flowering: August to October

Distribution: South of the Hawkesbury River, New South Wales, to Mt. Mee – Crows Nest in southern Queensland where it intergrades with var. *grandiflorum*.

D. speciosum Sm. var. *grandiflorum* F.M.Bailey, *Botany Bulletin*, Department Agriculture, Queensland 14, 12 (1896).

Syn. *Thelychiton rex* (M.A.Clem. & D.L.Jones) M.A.Clem. & D.L.Jones, *Orchadian* **13**, 492 (2002).

Plants very variable, epiphytic or lithophytic, larger rainforest forms epiphytic with well developed aerial roots; pseudobulbs erect, very long (up to 95 cm); leaves medium to large, up to 37 cm; racemes short to very long, 25–80 cm, 40–125 flowered; flower density from openly spaced to densely clustered; flowers small to some of the largest in the species, vertical height 4.7–8.2 cm, horizontal width 4.8–8.1 cm, from pale yellow to deep gold, occasionally bicoloured, rarely white, often with a very long dorsal sepal.

Flowering: August to October

Distribution: From Mt. Mee – Crows Nest in southern Queensland to Mt. Morgan in Queensland, and inland to Monto and Cania Gorge. Merges with var. *hillii* in the south, where flowers are smaller.

D. speciosum Sm. var. *capricornicum* Clemesha, *Orchadian* 7,103 (1982).

Syn. *Thelychiton capricornicus* (Clemesha) M.A.Clem. & D.L.Jones, *Orchadian* **13**, 491 (2002).

Plants very variable, many different forms on volcanic plugs and in forested areas; usually lithophytic without aerial roots, often short, compact and set in rock crevices; pseudobulbs to 19 cm long, usually cylindrical, curved with rigid, sometimes channelled leaves; racemes 17–50 cm, 11–68 flowered, with open to clustered arrangement; flowers small to medium sized, vertical height 3.4–5.9 cm, horizontal width 3.9–5.6 cm, white to deep gold, presenting from cupped to widely opened.

Flowering: May to August

Distribution: Just north of Mt. Morgan to Byfield and west to Berserker Range, Queensland.

D. speciosum Sm. var. *blackdownense* P.B.Adams, *Telopea* 11,195 (2006).

Syn. *Thelychiton coriaceus*, D.L.Jones & M.A.Clem., *Australian Orchid Research* **5**, 37 (2006), in part.

Plants very variable in size and shape; pseudobulbs to 30 cm long; leaves, racemes and flowers variable; racemes 23–60 cm long, 14–115 flowered; flower density varying from openly spaced to densely clustered, forming a brush; flowers small to medium sized, vertical height 3.5–5.4 cm, horizontal width 3.9–5.4 cm, off white to deep gold, usually opening widely; some similarities to var. *capricornicum*, but flowers later; usually less robust plants and flowers than is found in var. *carnarvonense*.

Flowering time: August to September

Distribution: Disjunct, from Expedition Range, Queensland to the northern limit of Blackdown Tableland, Queensland.

D. speciosum Sm. var. *carnarvonense* P.B.Adams, *Telopea* 11, 195 (2006).

Syn. *Thelychiton coriaceus*, D.L.Jones & M.A.Clem., *Australian Orchid Research* **5**, 37 (2006) in part.

Robust plants, usually lithophytic, often urn shaped, often but not always with wide based pseudobulbs to 33 cm long, tapering towards the apex; occasional aerial roots; rigid leaves similar to var. *speciosum*; racemes rather short, 20–50 cm, 25–87 flowered;

flowers of heavy substance, moderate size, vertical height 5.1–6.6 cm, horizontal width 5.5–6.3 cm, cream to gold, often cupped; similar to var. *speciosum* and some forms of var. *boreale* in northern Queensland.

Flowering: August to September

Distribution: Disjunct, in the gorges of the Carnarvon region, Queensland.

D. speciosum Sm. var. *curvicaule* F.M.Bailey, *Botany Bulletin*, Department Agriculture, Queensland 14, 12 (1896).

Syn. *Thelychiton spectabilis* D.L.Jones & M.A.Clem., *Australian Orchid Research* **S**, 42 (2006).

Plants very variable, pseudobulbs to 55 cm long, curved, fusiform or linear, sometimes with prominent edges in distal centimetres; aerial roots absent to prominent; racemes 20–65 cm long, 20–135 flowered, with open to closely spaced arrangement; flowers small to large, vertical height 4–7.2 cm, horizontal width 4.1–7.1 cm, white or cream to yellow, with some of the widest floral segments in the species.

Flowering: August to September

Distribution: St. Lawrence to Mt. Dryander, north of Prosperine and the Whitsunday Islands, Queensland. Intermediates between var. *curvicaule* and var. *capricornicum* occur south of Sarina.

Dendrobium speciosum Sm. subsp. *pedunculatum* (Clemesha) D.P.Banks & Clemesha

D. speciosum Sm. var. *pedunculatum* Clemesha. *Orchadian* 6, 261 (1981).

Syn. *Thelychiton pedunculatus* (Clemesha) M.A.Clem. & D.L.Jones, *Orchadian* **13**, 491 (2002).

Plants lithophytic, or infrequently found on bases of trees, short, compact; pseudobulbs to 36 cm long, often stout, erect or mildly curving; without aerial roots; leaves very coriaceous, often with purple pigmentation associated with high light exposure; racemes 16–60 cm, 9–72 flowered; peduncles often longer than the rachis, but may be considerably shorter; flowers small to medium sized, vertical height 2.8–4.5 cm, horizontal width 3.1–4.7 cm, off-white to yellow, open widely or cupped, well spaced or clustered forming a brush.

Flowering: July to September

Distribution: Lumholz National Park, south of Atherton Tableland, to Parker River headwaters, Queensland. This represents a narrow strip of open forest and rocky hillsides. Habitat, with intergrading forms between var. *pedunculatum* and var. *boreale*, has been much reduced by land clearance on the Tableland.

D. speciosum Sm. var. *boreale* P.B.Adams, J.M.Burke and S.D.Lawson, *Australian Systematic Botany* 19, 259 (2006).

Syn. *Thelychiton rupicola* D.L.Jones & M.A.Clem., *Australian Orchid Research* **S**, 40 (2006); *Thelychiton biconvexus* D.L.Jones & M.A.Clem., *Australian Orchid Research* **S**, 36 (2006); *Thelychiton curvicaulis* (F.M.Bailey) M.A.Clem. & D.L.Jones, *Orchadian* **13**, 491 (2002).

A very variable taxon in shape, habitat, pseudobulb shape and size; epiphytic and lithophytic; pseudobulbs from slender in southern part of range to broad, and tall, to 70 cm long and robust in northern part, variably curved, some northern forms sharply edged in distal half; racemes 18–80 cm long, 10–125 flowered; flowers small to medium sized, vertical height 3.1–5.2 cm, horizontal width 3.3–5.5 cm, white to pale yellow, usually well spaced, widely open and circular (star-like) in outline due to approximately equal vertical and horizontal presenting dimensions. Intergrades occur with var. *pedunculatum*, with peduncles of various lengths making identification difficult.

Key to subspecies of *Dendrobium speciosum*

1 Plants lithophytic, variable, leaf-bearing axes 5–71 cm long, peduncles shorter, equal or longer than the rachis, racemes with 10–125 flowers, white, cream, occasionally pale yellow, vertical height 2.8–5 cm, horizontal width 3.1–5.5 cm, usually presenting with approximately equal vertical and horizontal dimensions when flowers are well open. Plants of northern Queensland from Mt. Elliot to Cape Melville ..... **subspecies *pedunculatum***

1: Plants epiphytic or lithophytic, variable, leaf-bearing axes 10–95 cm long, peduncles shorter than the rachis, racemes with 11–240 flowers, white, cream, yellow to deep gold, vertical height 3.4–8.1 cm, horizontal width 2.9–8.0 cm, usually presenting with vertical dimensions greater than the horizontal. Plants occurring from eastern Victoria to Proserpine area, Queensland ..... **subspecies *speciosum***

Flowering time: July to September

Distribution: Mt. Elliot, south of Townsville, to Cape Melville (north Queensland).

Discussion

The subspecies are based on morphological results and well supported clades identified from ITS sequences (Burke *et al.* 2008; Fig. 1), and correlate well with geographic distribution (Adams *et al.* 2006a). Below this rank there are no consistent and reliable qualitative morphological characters to distinguish the varieties described in Adams *et al.* (2006abc). Most of the variability in the complex is due to variation in size and colour characteristics of floral parts, and to different sizes of leaves and stems. The two subspecies differ in horizontal and vertical dimensions of the open flowers. The dimensions of the northern subspecies are similar, conferring a rounded outline, while the vertical dimension is greater in the southern subspecies, producing a vertical oval outline. In general, the northern subspecies has smaller, less robust flowers, but these are also relatively frequent in var. *hillii*, var. *blackdownense*, var. *capricornicum*, and in var. *grandiflorum* in the southern part of its distribution range. The key to subspecies is based on combinations of morphological characters and distribution. It is not possible to construct a reliable key to the varieties due to the continuum of variability, and identifications are best made on the basis of detailed descriptions and especially on geographical origin of plants as outlined above and in Adams *et al.* (2006ac).

The northern and southern subspecies are separated by a relatively dry area of about 125 km from north to south, in the Burdekin basin between Mt. Elliot, the southern limit of var. *boreale*, and the Proserpine area, the northern limit of var. *curvicaule*. South of Proserpine, the five east coast varieties var. *curvicaule*, var. *capricornicum*, var. *grandiflorum*, var. *hillii*, and var. *speciosum*, in north to south order, occupy regions with some identifiable intergrading at parts of their margins (Adams *et al.* 2006ac). Prior to the molecular era, Banks and Clemesha (1990) raised the rank of all

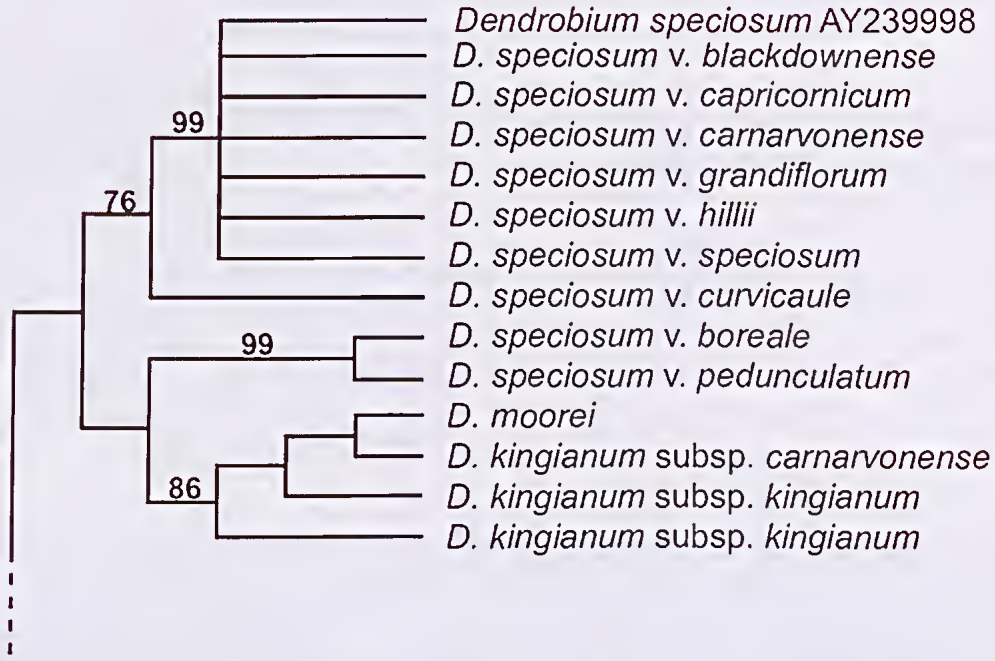

Figure 1. Phylogeny of *D. speciosum* on the basis of ITS sequence data. Part of a strict consensus tree of 51 most equally parsimonious trees, with *Dendrobium cunninghamii* as the outgroup. Numbers above branches are bootstrap values (adapted from Burke *et al.* 2008; *Aust. Syst. Bot.* http://www.publish.csiro.au/nid/150/paper/SB07038.htm).

previously described varieties to subspecies on the basis of separate distributions. More recent field work has revealed that the only significant breaks in the distribution of the complex are in the Burdekin basin, and the disjunct distribution of var. *blackdownense* and var. *carnarvonense*. Intermediates are found between varieties, especially between var. *hillii* and var. *grandiflorum*, but also in remote areas between var. *hillii* and var. *speciosum*, var. *grandiflorum* and var. *capricornicum*, and var. *curvicaule* and var. *capricornicum*.

The use of the name *pedunculatum* for the northern subspecies follows automatically from rules of priority (McNeill *et al.* 2006, Art. 11.4). It is unfortunate and somewhat confusing in that it has an entirely different connotation to that used previously. The variety *pedunculatum* occupies a very small distribution in comparison with var. *boreale*, and the vast majority of plants in the northern subspecies belong to var. *boreale* and lack the diminutive stature and long peduncles of var. *pedunculatum*.

The relationship of var. *curvicaule*, as a sister group to the six most southern varieties in the southern subclade (Fig.1), correlates well with its central adjacent geographic position and floral affinities. In the Clairview to Marlborough area, which has been poorly surveyed with respect to orchids, there are scattered small colonies with morphological features intermediate between var. *curvicaule* and var. *capricornicum* (Adams *et al.* 2006b). These plants have been numerically analysed, and in ordinations are outliers in the var. *curvicaule* cluster, supporting an intermediate status (Adams *et al.* 2006c).

Clements (1989), recognizing the above similarities, initially listed var. *capricornicum* as a variant of var. *curvicaule* on the basis of plant habit and habitat, before reconsidering it as a separate entity (Clements and Jones 2002). Variety *curvicaule* is the most confused name in the complex, as prior to 2006 it was used for plants from Eungella to Proserpine, and also for plants well to the north of the Burdekin basin in North Queensland. The northern plants have been numerically analysed and described as var. *boreale* (Adams *et al.* 2006b), and a neotype established for the Eungella-Proserpine group, which retained the name var. *curvicaule*. Previously Clements and Jones (2002) had proposed *Thelychiton curvicaulis* for *D. speciosum* var. *curvicaule* F.M. Bailey, referring to plants from the Eungella area, and also to plants north of the Burdekin Basin in North Queensland. Jones *et al.* (2006) then proposed *Thelychiton curvicaulis* for a north Queensland variant that we do not recognize as a distinct entity, but as part of *D. speciosum* var. *boreale*.

Using *D. cunninghamii* as an outgroup, analysis of ITS-DNA of all *Dendrobium* sect. *Dendrocoryne* species, including all of the *D. speciosum* taxa of Adams *et al.* (2006a) revealed a northern lineage of var. *pedunculatum* and var. *boreale* from north Queensland with 99% bootstrap support, and a southern lineage with 76% bootstrap support, including the six southernmost varieties with almost identical ITS sequences, and var. *curvicaule* (Burke *et al.* 2008) (Fig. 1). In Figure 1, var. *boreale* and var. *pedunculatum* are sister taxa to *D. kingianum* and *D. moorei*, but there is no support for this relationship in the consensus tree (Burke *et al.* 2008), in which the northern and southern subspecies represent separate clades. A feature of the ITS-DNA results is a very poor correlation between them and the morphological characteristics of described varieties throughout the distribution range. In central and southern Queensland, New South Wales and Victoria, there are almost no differences in ITS sequences in six varieties. North of Mackay, Queensland, the ITS variations do not correlate with a wide range of morphologies in three varieties. This marker is relatively uninformative in classification of the complex below the level of subspecies.

The preliminary cladogram of Jones *et al.* (2006) also indicates northern and southern lineages. Burke *et al.* (2008) rejected the recognition of *Thelychiton* as a distinct genus and the splitting of *D. speciosum* into eleven species as proposed by Jones *et al.* (2006). Several of these taxa – *T. biconvexus, T. rupicola, T. curvicaulis* and *T. epiphyticus* and their stated distributions, have not been evident as separate entities in our extensive field surveys, and the first three of these are regarded as habitat variants of var. *boreale*. At many sites, several of these may be found in close proximity in shaded and exposed situations and on different aspects of, for example, Mt. Lewis and Mt. Finnegan.

The classification presented above combines information from all available studies, refining the taxonomic hierarchy of the species to accord with the published evidence, while requiring the fewest taxonomic changes, one of the *desiderata* of the International Code of Botanical Nomenclature (McNeill *et al.* 2006).

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Isolation, characterisation and transferability of microsatellites for *Paraserianthes lophantha*, Cape Wattle (Leguminosae: Mimosoideae): a significant weed worldwide

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Introduction

Cape Wattle, *Paraserianthes lophantha* (Willd.) I.C.Nielsen (Leguminosae, Subfamily Mimosoideae, Tribe Ingeae), is a fast growing shrub/tree (to 15 m), endemic to south-west Western Australia (subsp. *lophantha*) and Indonesia (subsp. *montana* (Jungh.) I.C.Nielsen) (Cowan 1998; Nielsen *et al.* 1983). Subspecies *lophantha* was deliberately introduced to the east coast of Australia (Carr *et al.* 1992) and is now found throughout southern Australia, although there is a marked disjunction between populations of south-west Western Australia and eastern Australia. The exact limits of its natural geographic range are not clear as early collections (1848 – 1884) from several islands off Australia's south coast include subsp. *lophantha* (Cowan 1998; Robinson *et al.* 1981; Willis 1947).

Paraserianthes lophantha is an ecological, horticultural and economically important species, being planted for reforestation programs, as ornamental and shade trees, used as food, firewood, and also as substitute for soap (Nielsen *et al.* 1983, Nielsen 1992, Barneby and Grimes 1996, Lewis and Rico Arce 2005). The species has also become a significant weed worldwide. It is of such concern in South Africa researchers are investigating and implementing biological controls in an attempt to eradicate the weed (J. Wilson pers. comm.; Dennill and Donnelly 1991; Schmidt *et al.* 1999). Despite its ecological, horticultural and economic importance, nothing is known of the genetic variation within the species. Here we describe the first microsatellite markers specific to *P. lophantha*, which will be used to document the genetic structure and variation of the species throughout its current range to delimit the native distribution of this weedy species. The cross-transferability of these markers are assessed on genera of tribe Ingeae and species of *Acacia* s.s.

Abstract

We isolated microsatellite markers from *Paraserianthes lophantha* and screened these, plus eight loci from species of *Acacia s.s.* and *Pithecellobium*, for polymorphism in 42 individuals of *P. lophantha*: 20 from one native population and 22 from across the native and introduced range in southern Australia. Nine loci were polymorphic. Observed heterozygosity ranged from 0 to 0.800 (mean 0.389) and the number of alleles per locus ranged from 1 to 6 (average of 3.444) in the native population. Cross-species transferability of polymorphic loci was tested on eight species of *Acacia s.s.* and 11 of tribe Ingeae. Amplification success varied between loci and taxa; the ingioid taxa from South-East Asia and Australia amplified most successfully. These loci will be useful in understanding the genetic variation and control of this significant worldwide weed.

Keywords: Microsatellites; cross-species transferability; *Acacia sensu stricto*; tribe Ingeae.

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Materials and methods

Genomic DNA was isolated from 42 individuals of *P. lophantha* from dried leaves (herbarium specimens or silica gel dried) with the QIAGEN DNeasy Plant Mini Kit (QIAGEN Inc., Valencia, California) as per the manufacturer's protocol (Appendix 1). Microsatellite DNA loci were isolated, from one individual, following the biotinylated enrichment procedure of Murphy *et al.* (2009), which is based on the methods of Gardner *et al.* (1999; 2008). Positive clones were directly screened for microsatellite inserts via the three primer approach of Gardner *et al.* (1999). Those products that produced a smear on the agarose gel indicated the colony most likely included a microsatellite motif, while a strong single band indicated that no microsatellite was present.

One hundred and fourteen microsatellite-containing sequences (98%) were identified through sequencing 116 positive clones. To identify and eliminate motifs with similar flanking regions, which may represent non-unique loci, all sequences were analysed in the program MicroFamily (Meglécz 2007). Fifty-four potentially unique microsatellite loci were identified. For the 28 loci with eight or more dinucleotide repeats and four or more trinucleotide repeats, and with suitable flanking region, primers were designed in Primer3 (Rozen and Skaletsky 2000), and checked in NetPrimer (http://www.premierbiosoft.com/netprimer/index.html). Primers with a GC content of approximately 50% and a low 3' complimentarity were chosen.

Initial screening of the 28 loci was conducted with unlabelled primers on three individuals, including the individual used in development, to test for amplification. Each 10 µl reaction contained 1 µl 10X buffer, 0.88 mM dNTPs, 0.5 U HotStar *Taq*, 1 µM forward primer, 1 µM reverse primer, 1–11 ng of DNA and H_2O. The following PCR programme was used: 95°C for 15 min followed by 30 cycles at 94°C for 30 sec, 55°C for 30 sec, and 72°C for 30 sec; and a final elongation step at 72°C for 10 min. PCR products were visualised on a 1.5% agarose gel stained with ethidium bromide. Fourteen loci (50%) were successfully amplified for 10 individuals from across the geographic range then screened on a polyacrylamide gel to test for polymorphisms: eight loci were polymorphic, one was monomorphic, one did not amplify, and alleles in four loci were unclear.

Primers developed for related taxa were also assessed for amplification in *P. lophantha*: nine loci from *Acacia mangium* Willd. (Butcher *et al.* 2000: Am30, Am136, Am164, Am018, Am173, Am387, Am465, Am502, Am770), 10 loci from *A. saligna* (Labill.) H.L.Wendl. (Millar and Byrne 2007: As2.04, As2.13, As2.17, As2.20, As2.34, As2.46, As2.47, As2.57, As2.61, As2.62) and six loci from *Pithecellobium elegans* Ducke (Chase *et al.* 1996; Dayanandan *et al.* 1997: Pel1, Pel2, Pel3, Pel5, Pel6, Pel7). Of these, five from *A. mangium* (Am136, Am30, Am465, Am502, Am770) and three loci from *A. saligna* (As2.17, As2.46, As2.47) amplified individuals of *P. lophantha*, however, no primers for loci from *Pi. elegans* amplified products.

Using the Schuelke (2000) method, fluorescently labelled PCR was performed on 42 individuals (Appendix 1) — 20 from one population in the native range (BD, Leeuwin Naturaliste National Park, Boranup Drive, WA) and one individual from each of 22 locations across the native and introduced distribution range in Australia — for 16 loci: eight polymorphic newly isolated *P. lophantha* loci and eight loci (Am30, Am136, Am465, Am502, Am770, As2.17, As2.46, As2.47) developed for species of *Acacia* (Table 1). Each 25 µl reaction contained 5 µl Hot5tar master mix, 0.15 µl of 10 µM forward primer with tail, 0.5 µl of 10 µM reverse primer, 0.2 µl of fluorescently labelled 'M13' primer, 1–11 ng of DNA and H_2O. The same PCR programme as the unlabelled PCR was used. The fragments were run on a 3730 DNA Analyzer (Applied Biosystems) with a G5500LIZ_3730 size standard. Allele size and analyses were done with PeakScanner version 1.0 (Applied Biosystems).

Results and discussion

Nine of the 16 loci were polymorphic in *P. lophantha* from across the range tested. Genetic diversity parameters and tests for Hardy–Weinberg equilibrium and linkage equilibrium for these nine polymorphic loci were performed with GENALEX v. 6.3 (Peakall and Smouse 2006; Table 1) and GENEPOP v. 3.3 (Raymond and Rousset 1995) respectively, with significance values adjusted for multiple tests using a sequential Bonferroni procedure (Hochberg 1988). Null allele frequencies were estimated using CERVUS (Kalinowski *et al.* 2007) in samples from a single population (BD) only. The observed and expected heterozygosity from the select population (BD) ranged from 0 to 0.800 and 0 to 0.753 respectively, with means of 0.389 and 0.454. The number of alleles per locus in BD ranged from 1 to 6, with an average of 3.44. When all individuals were included, the number of alleles per locus ranged

Table 1. Characterisation of polymorphic loci. Primer sequences, Gen8ank accession number, repeat motif, and diversity characteristics of six microsatellite loci from *Paraserianthes lophantha* and three loci from species of Acacia s.s. (As2.17 and As2.46 from Millar & 8yrne (2007); Am465 from 8utcher et al. (2000)). N indicates the sample size; Na indicates number of alleles; ND indicates not done; 8D indicates samples from one population; PIC indicates polymorphic information content; * indicates significance after corrections for multiple tests; HWE indicates Test for Hardy-Weinberg Equilibrium.

Locus		Primer sequence (5'-3')	GenBank accession no.	Repeat motif	N - all (BD)	Allele size range - all (BD)	Na - all (BD)	Ho - BD only	He - BD	PIC - BD only	Null allele freq - BD only	HWE *P* - BD only
New loci:												
Plop4	F:	AAACCAAGGTCTTCTCTGCTTC	HQ449177	$(GT)_{24}$	42 (20)	192-218 (197-218)	10 (6)	0.650	0.753	0.713	0.0698	0.015
	R:	ACTCCCTCTCTTTCCATCTCT										
Plop6	F:	TGAAATGAGGGAGACGAGGA	HQ449178	$(GT)_{8}$	39 (19)	122-128 (122-126)	4 (3)	0.105	0.194	0.185	0.4446	<0.0001*
	R:	CACACATGTTCTCTCCTTACCTTG										
Plop8	F:	TTTGGCAGTCAGCAGAAGG	HQ449179	$(GT)_{5}GC(GT)_{12}$	42 (20)	163-203 (187-203)	10 (5)	0.500	0.729	0.68	0.1803	0.255
	R:	TTCTTCAATTTCCGTTCCATC										
Plop11	F:	TGTCAAACACACCTATCCACA	HQ449180	$(CA)_{16}$	42 (20)	221-243 (229-241)	11 (6)	0.800	0.728	0.681	-0.047	0.933
	R:	GACCGTCGGATCTGGAAGT										
Plop12	F:	GCATGTGACAATGGATGATTTC	HQ449181	$(TC)_{6}$	41 (20)	223-227 (223)	2 (1)	0	0	0	ND	ND
	R:	CATTCCTTCGCCATTCATTC										
Plop18	F:	ATTGAAGCTGCCCTCACATT	HQ449182	$(GT)_{3}(GC)_{2}(GT)_{5}$	42 (20)	178-180 (178-180)	2 (2)	0.500	0.480	0.365	-0.0204	0.852
	R:	TGTTCGGCCTCTTCTTTCTC										
Existing loci:												
As2.17	F:	TCCTCGCTTCTCGACATTTT	EF194135	$(AC)_{7}(TC)_{7}$	35 (15)	132-150 (132-150)	4 (3)	0.133	0.480	0.412	0.5585	<0.0001*
	R:	GCTCGAACCTTTCAAACGAA										
As2.46	F:	GTTCTCTTGCCCTGTTTGCT	EF194138	$(TC)_{7}$	42 (20)	120-126 (120-122)	3 (2)	0.550	0.489	0.369	-0.059	0.575
	R:	AGGCTGGAAATAAATGGAGGA										
Am465	F:	TGGGTATCACTTCCACCATT	FJ667822	$(AC)_{23}$	36 (19)	148-201 (148-150)	11 (3)	0.263	0.234	0.216	-0.0643	0.933
	R	AGGCTGCTTCTTTGTGCAGG										

from 2 to 11, with an average of 6.33. In our test population (BD), two loci depart significantly from Hardy–Weinberg Equilibrium after adjustments for multiple tests: Plop 6 and As2.17. Null alleles estimates are high for these two loci indicating they are probably not useful for routine analysis. No locus combinations exhibited significant linkage disequilibrium.

For all loci, except Plop18, the total number of alleles found in the 22 representative individuals was greater than the number of alleles found in population BD (Table 1): Plop6, Plop12, As2.17 and As2.46 had one more allele; Plop4 had four additional alleles; Plop8 and Plop11 had five extra alleles; and Am465 had seven additional alleles. Locus Plop12 was invariable in population BD (homozygous for allele 223), although individuals from five of the introduced populations EP, KI, LE, PI, RC (Appendix 1) had allele 227 as well as allele 223

To assess cross-species transferability, eight species of *Acacia s.s.* and 13 species of tribe Ingeae from across the phylogeny (Brown *et al.* 2008; Murphy *et al.* 2010) were screened for the nine polymorphic loci using the same protocol as above. No samples amplified for four loci: Plop6, Plop8, Plop11 and Plop12 (Table 2). Of the other six loci, amplification success varied: Plop18 did not amplify in any species of *Acacia s.s.*, while those taxa of tribe Ingeae from South-East Asia and Australia were the most successful, where three to five loci amplified respectively (Table 2).

These markers will be used to document the genetic diversity in *P. lophantha* to investigate the natural distribution of *P. lophantha*, which will inform management of populations in eastern Australia. Understanding the genetic variation and phylogeographic history of southern Australian populations of subsp. *lophantha* will also improve our knowledge of the evolution of *Acacia s.s.*, as *P. lophantha*

Table 2. Cross-amplification of nine loci on 21 species related to *Paraserianthes lophantha*. Number of species amplified, allele size range and number of alleles are summarised for taxa of *Acacia* s.s. and tribe *Ingeae*, with allele data for individuals noted below. * indicates tribe *Ingeae* species endemic to South-East Asia and Australia. – indicates no amplification.

	Plop4	Plop6	Plop8	Plop11	Plop12	Plop18	As2.17	As2.46	Am465
***Acacia s.s.* (8 species)**									
Number of species amplified	2	0	0	0	0	0	4	2	6
Allele size range (bp)	188-198	n/a	n/a	n/a	n/a	n/a	138-142	120-122	138-214
Number of alleles (Na)	3	n/a	n/a	n/a	n/a	n/a	3	2	9
Ingeae (13 species)									
Number of species amplified	5	0	0	0	0	6	6	6	11
Allele size range (bp)	176-224	n/a	n/a	n/a	n/a	158-178	138-142	120-134	164-224
Number of alleles (Na)	6	n/a	n/a	n/a	n/a	5	2	6	13
Alleles by taxon									
Acacia langifalia	–	–	–	–	–	–	–	122	–
Acacia melanaxylan	–	–	–	–	–	–	142	–	192, 212
Acacia murrayana	188	–	–	–	–	–	–	–	146, 214
Acacia parvipinnula	–	–	–	–	–	–	138	–	142
Acacia penninervis	–	–	–	–	–	–	–	–	140, 146
Acacia pulchella	–	–	–	–	–	–	–	–	178
Acacia saligna	196,198	–	–	–	–	–	138, 140	–	138, 146
Acacia victoriae	–	–	–	–	–	–	142	120	–
Abarema jupunba	–	–	–	–	–	–	–	–	180, 192
Albizia lebbeck	194, 196	–	–	–	–	178	142	126	166, 204
*Archidendran kanisii**	–	–	–	–	–	158, 172	142	–	172, 176
*Archidendrapsis basaltica**	196,224	–	–	–	–	174, 178	–	–	178, 184
Balizia elegans	–	–	–	–	–	–	138	–	164
Calliandra falialasa	–	–	–	–	–	–	–	–	–
Cajaba arbarea	–	–	–	–	–	–	–	–	–
Ebenapsis ebana	176	–	–	–	–	–	–	132	188, 224
Enteralabium cyclacarpum	–	–	–	–	–	–	–	132, 134	178
*Pararchidendron pruinasum**	190	–	–	–	–	176	142	122	121, 224
*Paraserianthes taana**	–	–	–	–	–	178	142	120	166
Samanea saman	–	–	–	–	–	–	–	–	188
*Wallaceadendran celebicum**	178	–	–	–	–	178	142	128	188, 198

has recently been identified as the closest relative of the Australian acacias (Brown *et al.* unpub.). These loci may also be useful in identifying source populations of introduced plants for better targeting biological controls.

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Appendix 1 Individuals used for DNA isolation and screening. Forty-two individuals that were isolated and screened for microsatellite loci developed for *P. lophantho* (this study) and other loci of related taxa (Butcher *et al.* 2000; Millar and Byrne 2007; Chase *et al.* 1996; Dayanandan *et al.* 1997) are listed. Locality details for populations the individual come from are given and each is assigned to be in either the native or introduced range.

Individual	Population location (population abbreviation)	Native/Introduced
GB207A	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207B	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207C	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207D	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207E	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207F	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207G	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207H	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207I	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207J	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207K	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207L	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207M	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207N	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207O	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207P	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207Q	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207R	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207S	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB207T	Leeuwin Naturaliste National Park, Boranup Drive, WA (BD)	Native
GB203B	Boat Harbour Rd, WA (BH)	Native
JW1_CA	Cape Arid National Park, WA (CA)	Native
GB204A	Donnelly River, WA (DR)	Native
JW3	Graphit Road, WA (Graphit)	Native
GB205A	Gingilup Swamps Native Reserve, WA (GS)	Native
JW2	South of Manjimup, WA (Manjimup)	Native
GB217A	Morangup Nature Reserve, WA (MR)	Native
JW6	Porongorup, WA (Poro)	Native
GB215A	Serpentine River, Serpentine Falls National Park, WA (SR)	Native
GB208A	Leeuwin Naturaliste National Park, Van Tripp Rd, WA (VT)	Native
P01	Recherche Islands, WA (RC)	Native
GB212C	Wellington Dam Rd, Wellington National Park, WA (WD)	Native
GB220A	Waterfall Gully, SA (WG)	Introduced
HO104070	Craggy Island, TAS (CI)	Introduced
HO444136	Devils Tower, TAS (DT)	Introduced
GB226A	White Flat Rd, Eyre Peninsula, SA (EP)	Introduced
GB224E	Kangaroo Island, SA (KI)	Introduced
GB229A	Lakes Entrance, VIC (LE)	Introduced
GB219A	Phillip Island, VIC (PI)	Introduced
GB22BB	Putney's Rd, near Mt Gambier, SA (PR)	Introduced
HO56079	Rodondo Island, TAS (RI)	Introduced
MJB1960B	Wye River, VIC (WR)	Introduced

a264855

Development and cross-species amplification of microsatellite markers from the endangered Wee Jasper Grevillea (*Grevillea iaspicula*, Proteaceae)

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Introduction

Grevillea is the largest genus of the Proteaceae (c. 357 species; Makinson 2000) and all but two species are Australian endemics. Grevilleas have diverse life-history characteristics, e.g., habits (prostrate shrubs – trees), mating systems (obligate outcrossers – mixed mating with varying degrees of self-fertility) and pollination syndromes (bird – insect). This diversity and the high proportion of species listed as rare or threatened (176 of 357 species, ROTAP; Briggs and Leigh 1996) has led to several studies investigating factors and processes determining the genetic structure of *Grevillea* species (e.g., England et *al.* 2001, 2002; Hoebee and Young 2001; Llorens et *al.* 2004; Holmes *et al.* 2008).

Informative molecular markers are essential for assessing diversity, gene flow and population dynamics. Several methods are available (see Glaubitz and Moran 2000) but microsatellites (or simple sequence repeats, SSRs) are particularly ideal, especially when they can be used in a variety of species. Within *Grevillea*, SSR primers have only previously been developed from *G. macleayana* (McGill.) Olde & Marriott (England et *al.* 1999). Here, the development of seven polymorphic SSRs from a *G. iaspicula*-derived genomic library is described. In addition, cross-species amplification of these markers is assessed, along with the polymorphism of six *G. macleayana*-derived SSR primer pairs in *G. iaspicula* McGill.

Grevillea iaspicula is endangered and has an extremely restricted and highly fragmented distribution in the Wee Jasper region of New South Wales, Australia (Hoebee and Young 2001). Conservation recommendations for this species have been in place since 1976 and an official recovery plan was established in 1991 (Butler et *al.* 1991). The mating system and genetic structure of *G. iaspicula* was assessed using allozymes (Hoebee and Young 2001), but high resolution SSR markers are necessary to evaluate contemporary connectivity of the extant populations via paternity and parentage analyses.

Abstract

Grevillea iaspicula is a highly restricted species occupying limestone outcrops near Wee Jasper, New South Wales (Australia). To allow future assessment of the ecological processes shaping the structure of *G. iaspicula* populations, seven polymorphic microsatellite (SSR) loci were developed from a partial genomic library. Amplification and polymorphism of six previously derived *G. macleayana* SSR primer pairs in the target species, *G. iaspicula*, were also assessed and cross-species amplification of SSR primers among several grevillea species is discussed.

Keywords: *Grevillea*, microsatellites, Proteaceae, SSRs, transferability

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Materials and Methods

Total genomic DNA was extracted from leaf tissue of *G. iaspicula* following Doyle and Doyle (1990). DNA was digested with *Sau*3AI, ligated into pUC18 and used to create a partial genomic library of c. 5500 clones containing 400-900 bp DNA inserts. Hybridisation of all combinations of 5'end-labelled [γ^{32}P]ATP di- and tri-nucleotide combinations, excluding AT/TA, identified over 180 positive clones. Plasmid DNA from positive clones was isolated using Wizard™ *Plus* Minipreps DNA purification systems (Promega). Of these, 67 were sequenced using ABI Prism™ BigDye™ Terminator Cycle Sequencing Ready Reaction Kit (Applied Biosystems).

Primers were developed for four pure and three interrupted dinucleotide SSRs as well as a single interrupted trinucleotide SSR (Table 1), following Löffert *et al.* (1997), and tested on nine *G. iaspicula* accessions (three plants from each of three *G. iaspicula* populations). The loci were amplified in a 20 µL PCR reaction (final concentration: 1 x PCR Buffer, 2.5 mM $MgCl_2$, 200 µM dNTPs each, 10 pmol/µL of each primer, 1 Unit *Taq* DNA polymerase, and 50 ng genomic DNA) using a touchdown procedure (2 cycles of 94°C for 1 min, 55°C for 30 sec, 72°C for 1 min, with sequential decrease of annealing temperature by 1°C every second cycle until 30 cycles of 94°C for 1 min, 50°C for 30 sec, 72°C for 1 min) and visualised on 3% agarose

Table 1. Details of primers developed for eight microsatellite loci in *G. iaspicula* with the structure of the repeat motif in, and the size (base pairs) of, the cloned allele. Primer and product information is followed by amplification results from a subset of nine individuals visualised on 3% agarose gels (P = polymorphic, M = monomorphic), as well as the number of alleles (N_A), heterozygosity (H_e) and product size range determined from 99 reproductive plants used in further analyses and where forward primers were radioactively labelled and loci visualised on 5% denaturing polyacrylamide gels. Polymorphism of some loci has also been established in other species, including GI7 (see text).

Locus	Repeat motif	Primer sequences (5'-3')	Product size (bp)	Product % GC	Optimal annealing temperature (°C)	Amplification Results	N_A / H_e / Product range (bp)	GenBank accessions
GI1F	$(GA)_4A(GA)_9$	CTCTCTTATCTCTCAAACTCAG	158	47.5	53.0	P	Not tested	DQ858446
GI1R		CTATTCGACGAAACCAAC						
G14F	$(AC)_{11}$	AACCATAAGGGCGACAAG	180	41.7	53.3	P	5 / 0.504 / 176-182	DQ858447
GI4R		GCCTACAGATATGGTGGAAC						
GI5F	$(TC)_8$	CAATAGCAGCAATAATGGAC	78	48.7	51.4	P	Not tested	DQ858448
GI5R		GCCCAGAGAAACAAAAAG						
GI6F	$(AG)_{13}$	AGCCACTTGTCTATCACTATC	93	44.1	50.0	P	Not tested	DQ858449
GI6R		TCTATCTATCCCCACTCTTC						
GI7F	$(TG)_2TA(TG)_7$	TCAACCTCTCTCCCTCTCAC	224	41.5	53.4	M	-	DQ858450
GI7R		CCTCCCAACCCATACATAC						
GI8F	$(GA)_2CT(GA)_9$	TTGTGGTGGGTAGAAGAG	442	41.2	53.4	P	Not tested	DQ858451
GI8R		TTGATGAAGAGTATGTGAGG						
GI9F	$(AG)_{13}$	GACAAAACCTTCCCAACC	206	43.7	53.8	P	9 / 0.795 / 190-212	DQ858452
GI9R		TCCATAATCGCATCTTCC						
GI10F	$(TTC)_8T(TTC)_2$	TGTAATATCGTACCACTGACC	126	42.1	51.4	P	Not tested	DQ858453
GI10R		TGTAAACTCAACCCCCTC						

gels. Additionally, six *G. macleayana* SSR primer pairs, which according to England *et al.* (1999) resulted in PCR product using *G. iaspicula* template, were re-tested for both amplification quality and polymorphism as described above.

A subset of six unlinked SSR loci (GI4, GI9, GM13, GM15, GM25 and GM37) was used to estimate heterozygosity in 99 reproductive *G. iaspicula* individuals (Tables 1 and 2). Loci were tested for Burrow's composite measure of linkage disequilibria between pairs of loci following Weir (1979) and were corrected for multiple tests using the Bonferroni procedure. Amplification followed the procedures described above with the exception that each forward primers was end-labelled with [γ^{33}P]ATP prior to PCR. Amplified products were diluted with 20 µL formamide loading dye and 2 µL of the mix was electrophoresed through a 5% denaturing polyacrylamide gel. The gels were fixed using standard procedures and the amplified products were visualised following 2 days exposure to BIOMAX™MR Scientific Imaging Film (Kodak).

Results and Discussion

Of the eight *Grevillea iaspicula*-derived loci, seven showed evidence of polymorphism (Table 1). The remaining locus (GI7) was monomorphic for all nine accessions (Table 1); it must be noted, however, that the resolution obtainable on agarose is insufficient to state this as absolute. With this in mind, GI7 has been shown to be polymorphic in other studies using fluorescently labelled primers and capillary electrophoresis (e.g. Llorens 2004; Whelan *et al.* 2006).

Four of the six *G. macleayana*-derived loci (GM13, GM15, GM25 and GM37) consistently amplified well in the *G. iaspicula* samples and all were polymorphic (Table 2). The observed size ranges in *G. iaspicula* typically bounded the original cloned allele (Table 2). In the one instance where observed allelic ranges exceeded the cloned allele size (GM15) it did so by only 10 base pairs. In *G. iaspicula*, GM12 and GM29 resulted in poor amplification and multiple priming sites, respectively. GM29 appeared to amplify two loci, only one of which was variable. This putatively polymorphic locus was much larger than the expected size of c. 141 base pairs (England *et al.* 1999) and it was not pursued further. Subsequent research by England *et al.* (2002) found variation at the GM29 locus to be within the left flanking sequence and not within the SSR motif.

Cross-species amplification of SSR loci is known to decrease with increasing evolutionary distance between source and non-source taxa (England 1999; Rossetto 2001). Nevertheless, England *et al.* (1999) showed that several *G. macleayana*-derived microsatellite markers were transferable to other grevilleas, including *G. iaspicula*. Treatment within the *Flora of Australia* suggests that these two species are distantly related: *G. macleayana*, with toothbrush-style inflorescences, is placed within the *Pteridifolia* group (*Aspleniifolia/Hookeriana* subgroup), as opposed to the placement of *G. iaspicula* within the *Floribunda* group (*Rosmarinifolia* subgroup) with spider-like inflorescences (Makinson 2000). The work presented here showed that not only were these markers transferable but that some loci are also polymorphic.

Table 2. Transferability and polymorphism of six *Grevillea macleayana* primers developed by England *et al.* (1999) to the target species, *G. iaspicula*. Heterozygosity was determined from 99 reproductive plants. Code key: ✓ = single polymorphic locus amplified in complete population assays; × = poor priming or multiple priming sites.

Locus	Repeat motif*	Expected product in *G. macleayana* (bp)*	*Grevillea iaspicula*			
			Transferability	Product range (bp)	No. of alleles	Heterozygosity (*He*)
GM12	$(AC)_9$	295	×	-	-	-
GM13	$(CT)_{23}$	139	✓	129-141	7	0.707
GM15	$(CA)_{10}$	134	✓	144-163	10	0.865
GM25	$(CT)_{15}$	252	✓	250-264	4	0.623
GM29	$(CT)_{15}$	141	×	-	-	-
GM37	$(CT)_8$	136	✓	130-154	7	0.786

*From cloned allele

Several of the *G. iaspicula*-derived SSR loci are also transferable and polymorphic in other species from this genus. For example, GI7 and GI9 are polymorphic in *G. macleayana* (Whelan *et al.* 2006), *G. caleyi* R.Br. and *G. longifolia* R.Br (Llorens 2004), and *G. repens* F.Muell. ex Meisn. (Holmes *et al.* 2008); GI9 is also polymorphic in *G. acanthifolia* A.Cunn. and *G. sphacelata* R.Br (Celebrezze 2002); and GI8 is polymorphic in *G. longifolia* (Llorens 2004). There is also evidence to suggest that the some loci amplify in other genera within the Proteaceae (*e.g., Macadamia*; J. Neal, pers. comm.). Transferability of SSR markers both within *Grevillea* and within the Proteaceae has both great economic potential and conservation value in that several proteaceaeous species are important forestry and crop species and, as noted above, many *Grevillea* species are rare or threatened taxa. The availability of genetic markers will lead to a better understanding of the population genetic structures of these species, which in turn will inform their utilisation or conservation.

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Contents

Volume 29(1), 2011

Contributed papers

Page

Six new infraspecific taxa in *Eucalyptus* (Myrtaceae) for Victoria 3
– K. Rule

Two new mallee Eucalypts (Myrtaceae) from Gippsland, Victoria 16
– K. Rule and W.M. Molyneux

Arthonia banksiae (lichenised ascomycetes) and its synonyms 27
– G. Kantvilas and V. Stasjic

An etymology of Australian bryophyte genera. 2 — Mosses 33
– D. Meagher

New combinations in *Dendrobium* (Orchidaceae) 62
– A. Schuiteman and P.B. Adams

New combinations and two new central Queensland taxa in the *Dendrobium tetragonum* (Orchidaceae:Epidendroideae) complex 69
– P.B. Adams

A new hierarchy conserving nomenclature for the *Dendrobium speciosum* complex (Orchidaceae: Epidendroideae) 81
– P.B. Adams, J.M. Burke and S.D. Lawson

Isolation, characterisation and transferability of microsatellites for *Paraserianthes lophantha*, Cape Wattle (Leguminosae: Mimosoideae): a significant weed worldwide 87
– G. Brown and S. Gardner

Short communication

Development and cross-species amplification of microsatellite markers from the endangered Wee Jasper Grevillea (*Grevillea iaspicula*, Proteaceae) 93
– S. Hoebbee